Decision **2003-020**

# Glacier Power Ltd.
# Dunvegan Hydroelectric Project
# Fairview, Alberta

**EUB Application No. 2000198**
**NRCB Application No. 2000-1**

**Report of the EUB-NRCB**
**Joint Review Panel**

**March 25, 2003**

NRCB
Natural Resources
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EUB
Alberta Energy and Utilities Board

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**Jointly released by**


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CONTENTS


1 Introduction ..... 1
1.1 The Application ..... 1
1.2 The Hearing and Participants ..... 1
1.3 Approval Process ..... 2
1.4 Project Description ..... 4

2 The Public Interest and the Panel's Approach to the Review of the Proposed Project ..... 5

3 Issues ..... 7

4 Project Need, Viability, and Benefits ..... 7
4.1 Views of the Applicant ..... 7
4.2 Views of the Interveners ..... 8
4.3 Views of the Panel ..... 10

5 Effects on the Ice Regime of the Peace River ..... 11
5.1 Impacts of the Project on the Peace River Ice Regime ..... 11
5.1.1 Views of the Applicant ..... 11
5.1.2 Views of the Interveners ..... 14
5.1.3 Views of the Panel ..... 17
5.2 Impacts on Flooding at the Town of Peace River ..... 18
5.2.1 Views of the Applicant ..... 18
5.2.2 Views of the Interveners ..... 22
5.2.3 Views of the Panel ..... 25
5.3 Impacts on Seepage Flooding and Storm Water Outfalls ..... 27
5.3.1 Views of the Applicant ..... 27
5.3.2 Views of the Interveners ..... 28
5.3.3 Views of the Panel ..... 28
5.4 Impacts on the Shaftesbury Crossing ..... 28
5.4.1 Views of the Applicant ..... 28
5.4.2 Views of the Interveners ..... 30
5.4.3 Views of the Panel ..... 31
5.5 Impacts on Wildlife Movements Across the River ..... 32
5.5.1 Views of the Applicant ..... 32
5.5.2 Views of the Interveners ..... 32
5.5.3 Views of the Panel ..... 33

6 Effects on the Peace River Fishery ..... 33
6.1 Fish Populations of the Peace River ..... 33
6.1.1 Views of the Applicant ..... 33
6.1.2 Views of the Interveners ..... 34
6.1.3 Views of the Panel ..... 34


(continued)

6.2 Impacts on Upstream Fish Passage ..... 35
6.2.1 Views of the Applicant ..... 35
6.2.2 Views of the Interveners ..... 37
6.2.3 Views of the Panel ..... 38
6.3 Impacts on Downstream Fish Passage ..... 39
6.3.1 Views of the Applicant ..... 39
6.3.2 Views of the Interveners ..... 42
6.3.3 Views of the Panel ..... 43
6.4 Impacts on Fish Habitat ..... 44
6.4.1 Views of the Applicant ..... 44
6.4.2 Views of the Interveners ..... 45
6.4.3 Views of the Panel ..... 45
6.5 Impacts on Fish Populations ..... 45
6.5.1 Views of the Applicant ..... 45
6.5.2 Views of the Interveners ..... 47
6.5.3 Views of the Panel ..... 48

7 Other Project Effects ..... 49
7.1 Impacts on the Peace-Athabasca Delta ..... 49
7.1.1 Views of the Applicant ..... 49
7.1.2 Views of the Interveners ..... 49
7.1.3 Views of the Panel ..... 51
7.2 Transportation Effects ..... 51
7.2.1 Views of the Applicant ..... 51
7.2.2 Views of the Interveners ..... 52
7.2.3 Views of the Panel ..... 53
7.3 Effects on Downstream Communities ..... 53
7.3.1 Views of the Applicant ..... 53
7.3.2 Views of the Interveners ..... 53
7.3.3 Views of the Panel ..... 54

8 Public Consultation Process ..... 55
8.1 Views of the Applicant ..... 55
8.2 Views of the Interveners ..... 56
8.3 Views of the Panel ..... 56

9 Panel Findings ..... 57
9.1 Economic and Social Impacts ..... 57
9.2 Environmental Impacts ..... 59
9.3 Decision ..... 60

Table 1. Those Who Appeared at the Hearing ..... 61

# 1 INTRODUCTION

## 1.1 The Application

On June 19, 2000, Glacier Power Ltd. (Glacier) submitted an application to construct and operate a 40 megawatt (MW) run-of-river hydroelectric project on the Peace River approximately 2 kilometres (km) upstream of the Dunvegan Bridge on Highway 2 (see Figure 1). It submitted an application to the Alberta Energy and Utilities Board (EUB) for authorizations under Sections 7, 8, 11, 12, 14, and 17 of the Hydro and Electric Energy Act (HEE Act)[1] to construct and operate a hydroelectric facility.

Glacier also submitted an application to the Natural Resources Conservation Board (NRCB) for an approval under Section 4 of the Natural Resources Conservation Board Act (the NRCB Act) to construct and operate a water management project for which, under the Alberta Environmental Protection and Enhancement Act, an environmental impact assessment (EIA) was required. The EUB and NRCB applications were submitted concurrently, and since they consist of the same information, are hereinafter referred to as the "Application".

Section 3 of the Energy Resources Conservation Act (ERC Act) requires the EUB to consider whether a proposed project is in the public interest having regard to the social and economic effects of the project and its effects on the environment. Section 2 of the NRCB Act provides that the NRCB must have regard for the same factors. In order to conduct an effective and efficient review of the project, the EUB and the NRCB (the "Boards") agreed to consider the Application at a cooperative proceeding pursuant to Section 21 of the NRCB Act and Section 22 of the ERC Act. A Panel consisting of members and acting members from both Boards (the "Panel") was designated by the Boards to consider the Application.

## 1.2 The Hearing and Participants

On June 19, 2000, Glacier submitted its Application, including the EIA, to the EUB, NRCB, and Alberta Environment (AENV). The three agencies provided public notice of the filing of Glacier's Application in local newspapers in July 1999, noting the locations where copies of the Application and EIA could be viewed.

On June 16, 2001, the Panel held a prehearing conference at Fairview College in the Town of Fairview, Alberta, to solicit comments from the company, government representatives, nongovernmental groups, and the public on preliminary matters in order to facilitate an efficient and effective hearing. The Panel presiding at the prehearing conference consisted of Brian Bietz

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[1] Note that the section numbers identified relate to the statutes as they existed at the time of the initial application (*R.S.A. 1980*) and may not correspond to the section numbers in the current statutes (*R.S.A. 2000*).

(Chairman), Jim Dilay, and Gordon Miller. Based on input from the participants, the Panel decided to commence the hearing on October 2, 2001, in the Town of Fairview and provided a timetable for the exchange of information prior to the hearing.

The hearing commenced in Fairview on October 2, 2001. The Panel presiding at the hearing consisted of Brian Bietz (Chairman), Gordon Miller, and Carolyn Dahl Rees. At the commencement of the hearing, Glacier sought an adjournment so that it could provide the additional information on fish and ice issues requested by federal and provincial government agencies. Various interveners provided the Panel with their views on the issue of an adjournment and the associated timeline.

The Panel agreed to adjourn the hearing and set June 17, 2002, as the date that the hearing would resume in Fairview. Further, the Panel established a new timetable for the filing of additional information by all parties.

On April 5, 2002, Alberta Justice notified the Panel that one of AENV's experts would be unable to attend the hearing if it were to recommence in June 2002, and it indicated that AENV might have to request that the hearing be adjourned or that part of the hearing be extended so that its expert could provide evidence.

Glacier responded that, in its view, recommencing the hearing at a later date would be in the best interests of all parties. It noted that this would both allow AENV's expert to participate in the hearing and provide it with extra time to further refine the design of the fish passage structures.

Having considered the views of Glacier, Alberta Justice, and other parties, the Panel decided to reconvene the hearing on October 16, 2002. The Panel determined a new timetable for the filing of additional information.

The hearing was reopened on October 16, 2002, in Fairview. The Panel presiding at the hearing consisted of Brian Bietz (Chairman), Ian Douglas, Carolyn Dahl Rees, and Robert Powell. Following oral testimony and cross-examination, the Panel determined that written final argument was appropriate and the parties filed their written argument by October 30, 2002. Glacier's reply argument was filed with the Panel on November 1, 2002. The Panel considers the close of proceedings for this Application to be November 1, 2002.

A list of those parties and individuals who participated in the proceeding is attached as Table 1.

### 1.3 Approval Process

In addition to NRCB and EUB approvals, the Dunvegan project requires approvals from various other provincial and federal regulatory agencies, including AENV, the Fish and Wildlife Division of Alberta Sustainable Resource Development (SRD), and the Department of Fisheries and Oceans (DFO).

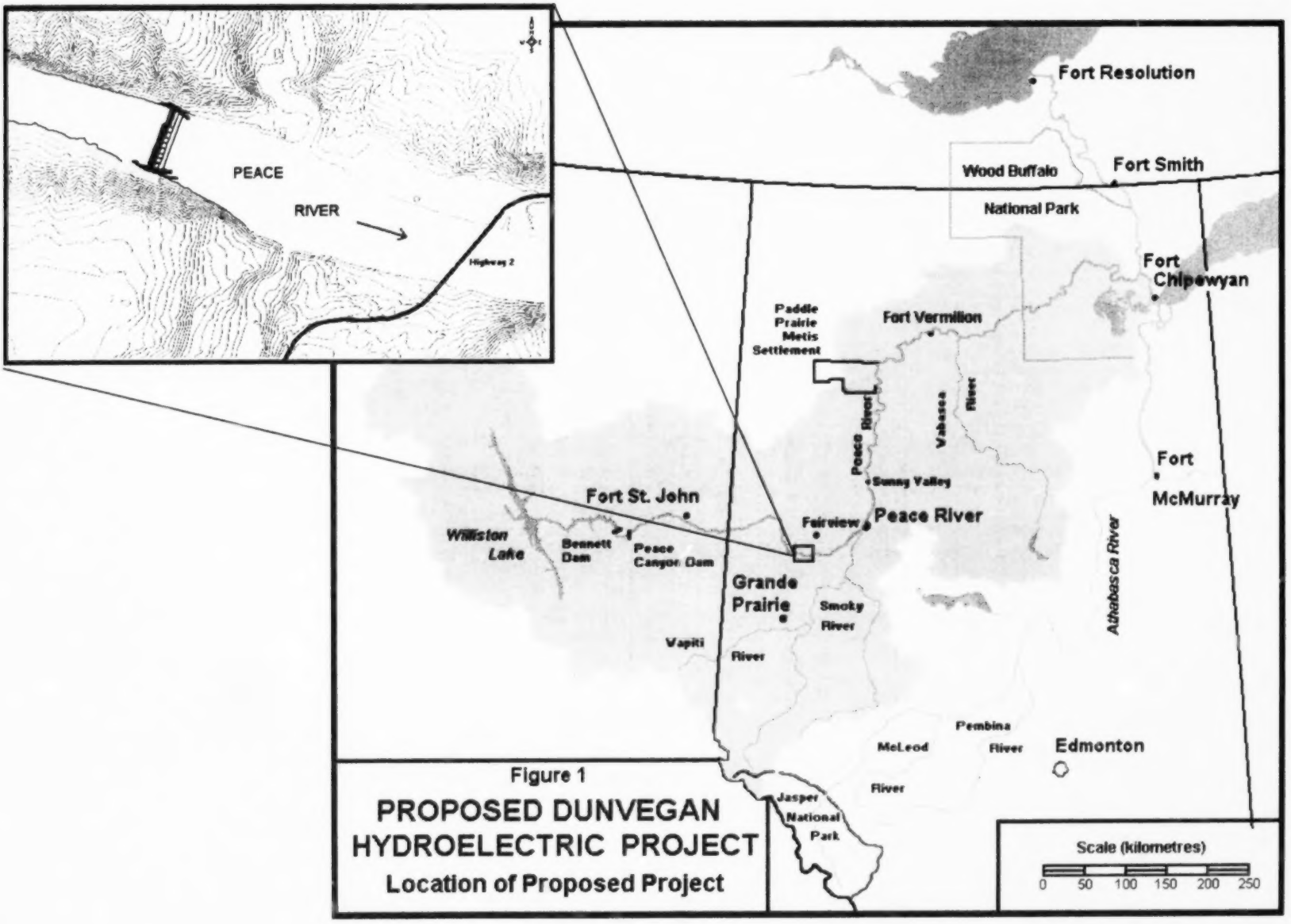



Figure 1

**PROPOSED DUNVEGAN HYDROELECTRIC PROJECT**

**Location of Proposed Project**

In June 1999, AENV advised Glacier that it would be required to prepare and submit an EIA for the proposed Dunvegan Hydroelectric Project. As the Government of Canada would also be undertaking a review of the proposed project under the federal Fisheries Act and the Navigable Waters Protection Act, the review of the environmental effects of the project proceeded according to the terms of the Canada-Alberta Bi-Lateral Agreement for Environmental Assessment Cooperation. As such, both federal and provincial regulators (DFO, the Canadian Environmental Assessment Agency, NRCB, EUB, SRD, and AENV) jointly assisted in the preparation of the final terms of reference for the EIA and jointly participated in the review of the Application. At the hearing, AENV, SRD, and DFO stated that they would defer any determination of the matters before them until after the Panel had issued its decision on whether the project was in the public interest.

### 1.4 Project Description

In its original June 2000 Application, Glacier characterized the project as being a low-head (6 metre [m]) modular hydro facility. Glacier noted that the headpond above the structure would extend approximately 22 to 26 km upstream, inundate between 100 and 150 hectares of land, and be contained within the natural river channels below the pre-Bennett Dam 1:100 year flood levels.

Glacier described the project as consisting of six components:

- a 232 m fixed crest weir/spillway,
- forty 1 MW turbine units, with a cumulative width of 168 m,
- a navigation lock,
- two fishways for fish migration,
- a 138 kilovolt (kV) power transmission line to one of two interconnection points, and
- a permanent road access to the north side of the structure.

In its March 15, 2002, response to requests from the regulatory authorities for supplemental information, Glacier also submitted a revised project description. While the location and general size of its proposed facility remained unchanged, Glacier indicated that it was now seeking approval for an 80 MW facility, rather than the original 40 MW, with the following features:

- a 150 m fixed crest weir/spillway,
- forty 2 MW turbine units, with a cumulative width of 250 m,
- a navigation lock,
- two 50 m wide rockfill ramps to allow fish passage, one located at each end of the weir/spillway structure,
- a 144 kV power transmission from the south end of the structure to an existing ATCO Electric Ltd. transmission line, and
- a permanent road access to the south side of the structure.

Glacier noted that the original design had been changed to incorporate new, larger turbine technology that would double the power output and to include an optimized fishway design that was developed in consultation with DFO and SRD.

In August 2002, Glacier submitted an *Information Update* that contained a third project configuration, as well as an updated assessment of project impacts. This third version was similar to the previous design with the exceptions that:

- flow through the facility was increased from 1624 cubic metres per second ($m^3/s$) to 1800 $m^3/s$,
- the fixed crest weir/spillway was reduced in length to 110 m,
- the width of the powerhouse containing the forty 2 MW turbine units was increased to 285 m,
- the two fishways, located at each end of the structure, were decreased in width to 10 m, and
- downstream fish bypass structures were now included in the design of the powerhouse.

When the hearing recommenced in October 2002, Glacier's testimony was based on this project configuration. Details of the proposed design of the structure are provided in Figure 2.

## 2 THE PUBLIC INTEREST AND THE PANEL'S APPROACH TO THE REVIEW OF THE PROPOSED PROJECT

As noted above, both Boards are required to consider the social, economic, and environmental effects of a proposed project. The primary difference between the mandates of the EUB and the NRCB when assessing the proposed Dunvegan Hydroelectric Project arises with respect to the question of the need for the project.

Under Sections 9, 10 and 12 of the HEE Act and Section 3 of the ERC Act, the responsibility of the EUB is to consider whether the construction and operation of a proposed hydro development and power plant is in the public interest. In addition to the above factors, the HEE Act also requires the EUB to take into account the economic, orderly, and efficient development of hydro energy and the generation and transmission of electric energy in Alberta.

With the 1995 enactment of the Electric Utilities Act (EU Act) and the concurrent amendments to the HEE Act, the Alberta legislature expressed a clear intention that electrical generation in Alberta was now to be developed through the mechanism of a competitive, deregulated electrical generation market and not through the former regulatory regime, which required the EUB to determine the need for the facilities, sequence of construction, and commissioning of such facilities and the allowed cost of such facilities in rates, as well as the price of electricity to be charged to consumers through regulated rates. The effect of this legislative change and the EUB's position on the relevance of need for a power plant as part of its regulatory mandate is further discussed in *Decision 2001-111* (Epcor Genesee), *Decision 2001-33* (Epcor Rossdale), *Decision 2002-101* (AES), and *Decision 2002-14* (TransAlta Keephills).

Because the proposed project represents a water management project, as per Section 4 of the NRCB Act, approval from the NRCB is also required. However, the NRCB is not as legislatively constrained from considering the issues of need and cost when assessing whether a reviewable project is in the public interest. The NRCB has historically examined these issues as a part of its overall consideration of the public interest and in its assessment of the social and economic effects of the proposed project. Furthermore, Glacier, in both its written submissions and its testimony, addressed both the need for and cost of the project. A number of interveners also addressed these issues in their submissions.

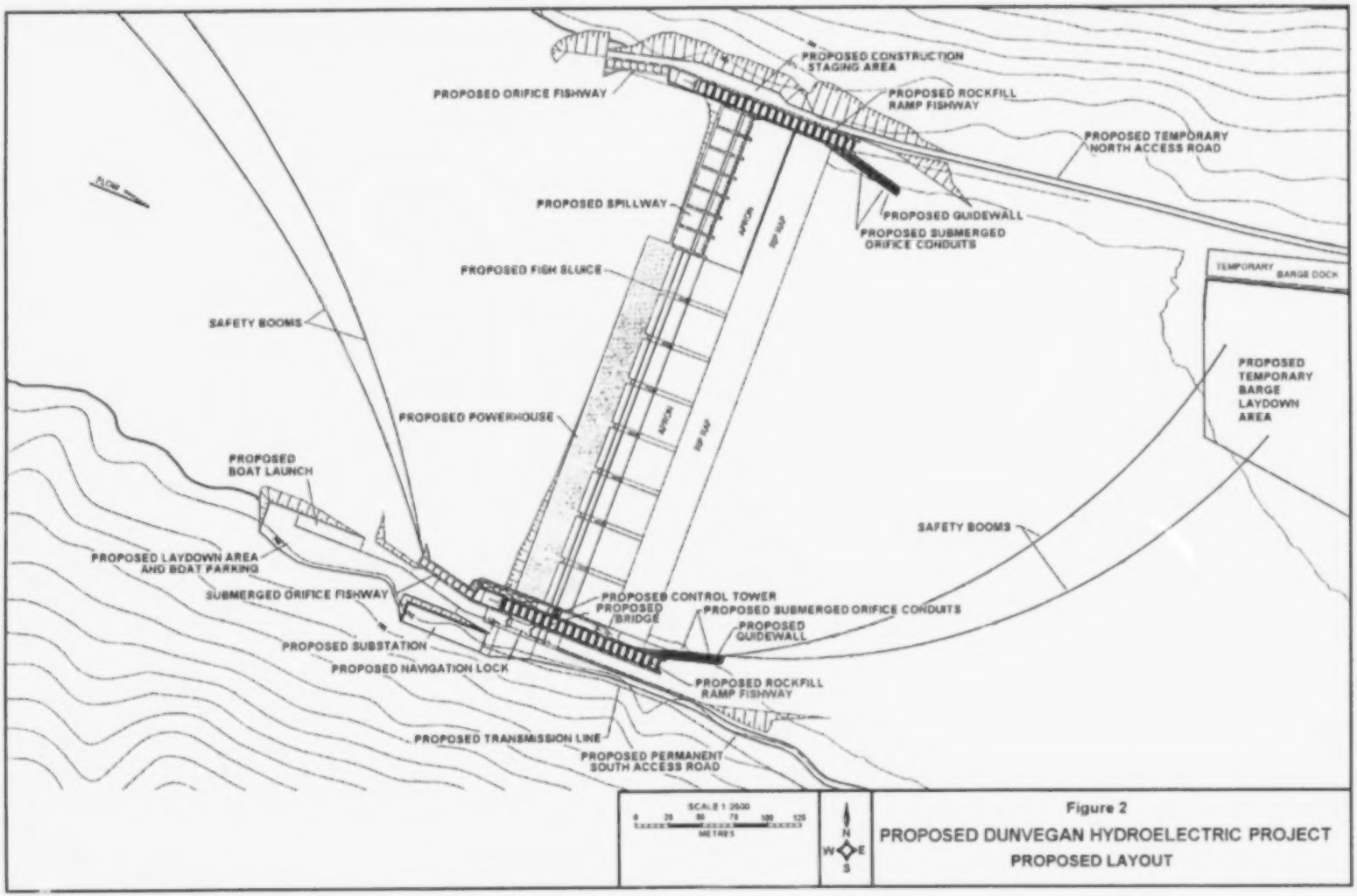



Figure 2

PROPOSED DUNVEGAN HYDROELECTRIC PROJECT

PROPOSED LAYOUT

Faced with this potential legislative dichotomy, the Panel carefully considered what would be the appropriate approach. The Panel noted that in assessing the public interest, it is routinely necessary for both Boards to balance broad economic, social, and environmental benefits and costs. The existence of regulatory standards and guidelines and a proponent's adherence to these standards are important elements in deciding whether potential adverse impacts are acceptable. And, where impacts are not established in standards or guidelines, the onus is on the applicant to demonstrate that reasonable mitigative measures can be used to address the impacts. Furthermore, in many cases, an application may also be approved subject to specific conditions designed to enhance the effectiveness of the mitigative plans. The conditions become an integral part of the approval; breach of them may result in suspension or rescission of the approval. For example, the issue of public health and safety is a fundamental component of the public interest when reviewing power plant applications. For an applicant to obtain approval for such a project, it must satisfy the Boards that the construction and operation of its electric generation plant will not jeopardize public health and safety.

Even when such standards are met, however, it is still common for a particular project to have net environmental and social costs relative to the no-project option. In those cases, some countering benefit, most often demonstrated in terms of net economic or social benefits, must exist for the project to be found to be in the overall public interest. In considering the public interest mandates of both Boards, the Panel determined that the issues of the need for and the economic costs and benefits of the Dunvegan project should be considered as part of its overall assessment of whether approval of the project would be in the public interest.

## 3 ISSUES

The Panel believes the issues related to this Application to be:

- project need, viability, and benefits
- effects on the ice regime of the Peace River
- effects on the Peace River fishery
- other project effects
- public consultation process

## 4 PROJECT NEED, VIABILITY, AND BENEFITS

### 4.1 Views of the Applicant

Glacier submitted that the Dunvegan project would address local and regional needs for power in a region where, historically, residents and industry had experienced frequent voltage control problems, including power outages and spikes. Glacier said its project would provide stable and secure electric power in the local area and in the region. To support its view, it cited a letter from the Transmission Administrator, ESBI Alberta Inc., which stated that "given the continuing load growth in northwestern Alberta, the Dunvegan facility will help to meet load growth in the region" by improving local voltage profiles and power flow.[2] However, Glacier also stated at the

[2] Hearing Exhibit 46. Letter dated October 11, 2002, to Tom Chan, EUB, from Neil J. Brausen, P.Eng. Manager, Long Term Planning, ESBI, Transmission Administrator of Alberta.

hearing that it had not studied any patterns of brownouts or reductions in reliability in the area and further stated that it could not say if the project would statistically reduce blackouts or power shortages. Glacier noted that none of the hearing participants had provided evidence stating that the project was not needed and submitted that it had provided sufficient evidence to conclude that there was a need for the project.

Glacier suggested that additional electric power generation from the Dunvegan project would promote economic growth and development in the region, but without the air emissions problems associated with other types of generating facilities. Glacier submitted that power from Dunvegan would benefit air quality through displacement of coal-fired or gas-fired generation, thereby reducing a variety of contaminants, and that this would improve the health and well-being of Albertans.

Glacier said it had employed realistic third-party long-term projections of the market price for electric power in assessing the economic viability of its project. It suggested that the power from the Dunvegan project would be priced competitively with the power from gas-fired generation, even without considering any price premiums that may be paid for green energy. Glacier noted that it believed that the proposed project qualified as a renewable low environmental impact power source under Environment Canada's Environmental Choice Program and could be certified to use the EcoLogo$^{M}$ label, since the project headpond would have fewer than four days of storage.

Glacier suggested that the capital cost of the project would be approximately $200 million, including a 15 per cent contingency. Glacier indicated that after receiving approval from the Boards, it intended to finance about three-quarters of the cost of the project by securing energy contracts. Glacier testified that the economic viability of the project depended upon its ability to sell the electricity produced by the project for $45 to $50 per megawatt hour, but predicted that it would likely be able to market the electricity produced for $50 to $70 per megawatt hour.

Glacier submitted that the project would provide local and regional social and economic benefits. It estimated that construction of the facility would require 300 worker years over a two-year period, and it committed to employ local contractors to the degree practical. It also estimated that about one-third of project costs would be spent in the region. Glacier predicted that three to six full-time staff would be required to operate the project, and it said that hiring of local contractors for maintenance and repair would generate some local benefits.

Further, Glacier stated that the project would generate approximately $1 million per year in municipal taxes for the Municipal District (MD) of Fairview. It also submitted that the project would generate tax revenue for the provincial and federal governments and waterpower rentals for the provincial government.

### 4.2 Views of the Interveners

Ms. Charchuk, the Mayor of the Town of Fairview, stated that there was a real need for additional power in Alberta. She expressed concern about potential brownouts or blackouts resulting from the lack of electricity. She indicated that the project would improve the quality of life for residents of northern Alberta. Ms. Charchuk noted that Fairview was often subject to power outages, although she also stated that she did not know the exact cause of these outages.

Mr. Sawchuk stated that he was appearing at the hearing both on his own behalf and on the behalf of local Rural Electrification Associations (REAs). He stated that the project could be beneficial to the five adjacent REAs provided that legislative revisions allowed the REAs to obtain electricity directly from a supplier through their own system facilities, thereby eliminating transmission system costs.

Mr. Sawchuk also stated that the project would provide needed generation in a cost-effective and environmentally friendly manner. He stated that the project would eliminate strain on the regional transmission system and would lower line loss, thus resulting in lower electricity costs. Mr. Sawchuk stated that the project would provide additional revenue and employment for the area and an increased tax base. Further, Mr. Sawchuk suggested that the project would enhance customer choice and create competition that would result in lower electricity prices. Mr. Sawchuk also noted that the project might increase tourism in the area.

Mr. Doll stated that he is a local resident and taxpayer in the Fairview area and that he supported the project. He suggested that taxes paid by the project would allow the MD of Fairview to reduce mill rates and that this would benefit local farmers.

The Friends of the Peace, a group of about 100 to 150 residents of northern Alberta, acknowledged that there might be some small economic benefit associated with the project but argued that the potential negative effects of the project, including environmental effects, were not yet understood. They suggested that more research was required in order to effectively understand the impacts of the project upon the Peace River ecosystem.

The Town of Peace River indicated that it was not convinced that the additional power provided by the Dunvegan project was needed. It noted that the local demand for power was likely decreasing because of declines in the rural population and suggested that the true market for power from the project was elsewhere in Alberta. The Town of Peace River also disagreed with the suggestion that the project would increase the reliability of the grid in the local area, observing that the recent power outages in parts of Fairview, as reported anecdotally by Ms. Charchuk, were probably due to neighbourhood distributional problems and not regional supply problems.

The Town of Peace River also challenged the conclusion that the municipal taxes to the MD of Fairview would be about $1 million annually. It noted that municipal taxes would decrease over time because the assessed value of the machinery and equipment would depreciate. The Town of Peace River pointed out that if the development of the project ultimately led to an increased probability of flooding in the Town of Peace River (see Section 5.2), the adverse economic and social impacts would be enormous and could not be mitigated. It stated that the potential benefits for the Town of Fairview and the surrounding area would be more than offset by the resulting negative impacts that would be borne by residents of the Town of Peace River.

BC Hydro and Power Authority (BC Hydro) stated that it currently owns and operates two hydroelectric generation stations on the Peace River and did not oppose additional hydroelectric development. It submitted that approval of the project could also provide it with some generation benefits if it were to reduce the number of days during which it was expected to control the releases from its facilities to address ice management concerns in Alberta (see Section 5.2). BC Hydro explained that it currently is expected to reduce flows during critical periods in the winter

to help avoid flooding at the Town of Peace River and that such controls could result in the loss to it of up to 9.3 gigawatt-hours per day (GWh/d) of generation from its Peace River plants. It stated that if the project were approved and the critical ice thickness proposal brought forward by Glacier (see Section 5.2) were adopted, the number of days during which it would operate these generation facilities under flow controls could be reduced.

Ms. Liefbroer-Chenard, speaking on behalf of DC Farms and other residents of the community who used the Shaftesbury ferry in the summer and the ice bridge in the winter, said that the project could have serious economic and social impacts on their community. She stated that the ice bridge was commonly used by local residents and provided safe and timely access across the Peace River during the winter months when the ferry was not operational. She submitted that if the project resulted in delays in the formation of the ice bridge, the result would be a significant increase in travel times for residents travelling to centres such as the Town of Peace River.

Ms. Liefbroer-Chenard's interpretation of Glacier's evidence was that changes in the ice regime associated with the project would allow the Shaftesbury ice bridge to be constructed only in cold and very cold winters (see Section 5.4). As a result, local residents would be forced to drive long distances to reach destinations that were much more proximate when the ice bridge was in place. She suggested that this would have a significant impact upon residents' quality of life and negatively affect property values.

### 4.3 Views of the Panel

As stated in Section 2, in order to establish whether the project is in the public interest, the Panel must understand its potential economic, social, and other benefits and then determine whether these balance or outweigh the project's costs and negative impacts on the environment, public health, and safety and other social and economic matters.

The Panel agrees that the project, if approved, would provide some local benefits to the Fairview/Dunvegan area. These would include at least a short-term infusion of capital and employment during the construction phase of the project, as well as some minor longer-term employment during the operational phase, ongoing maintenance of the facility, and an increase in the local tax base. However, the Panel notes that the actual extent of economic benefits to the existing labour pool and infrastructure in the region during the construction phase would depend on the capacity of the local labour markets, such that the benefits would be reduced proportionately if the project were constructed during a period of relatively high local economic activity.

With respect to regional benefits, the Panel agrees that the project, if approved, could generate tax revenue for municipal, provincial, and federal governments. While the Panel notes that the Town of Peace River had observed that over time the impacts of depreciation would gradually erode municipal tax revenues, it also recalls Glacier stating that since the market value of the project would likely rise over time, municipal tax payments would not decline. Without having more information on municipal taxation practices and the policies of the local municipalities on the record, the Panel is unable to comment on how the project might impact future municipal tax revenues.

With respect to the suggestion that approval of the project also would increase the reliability of electricity service and the stability of the electricity supply in the region, the Panel is not fully convinced that the project would, in fact, have a material impact upon either local electricity reliability or supply. The Panel notes that the evidence with respect to local electricity problems was primarily anecdotal. The Panel is of the view that, in the absence of any clear evidence on the point, the occurrence of such problems cannot be attributed to the regional distribution system, generation facilities, or the transmission grid.

The Panel notes the desire of the REAs in the area to obtain a direct link to a generating facility and thereby avoid the transmission grid and associated province-wide transmission charges. However, the Panel agrees with Mr. Sawchuk that the governing legislation today would not permit such bypass of interconnected electric system charges by REAs. Therefore, the Panel is not convinced that the economic benefits of local generation as desired by the REAs are likely to occur, at least in the foreseeable future.

In assessing the potential economic benefits of the project, the Panel believes that it must also consider the risk that the expected revenues would actually be generated. Possible risks include potential operational constraints that may prevent the project from achieving the projected power output, which are discussed elsewhere in this report, and whether the market value of the power produced would be less than predicted. With respect to this latter issue, Glacier noted that it would not proceed with project construction until such time as it had signed contracts that would generate the necessary revenues.

The Panel notes that there was some discussion of potential project impacts outside Alberta, primarily in terms of whether, as a result of the potential impacts on the ice regime of the Peace River, changes in flow controls would affect BC Hydro's ability to generate power. While the Panel appreciates the potential implications of changes in the duration of flow controls (which result in losses to BC Hydro of up to 9.3 GWh/d of potential generation from the Peace River plants) and the potential benefit to BC Hydro of any reductions in these requirements, there is no clear evidence on the extent to which the project would potentially affect BC Hydro's overall operations or the resulting effects on British Columbia (B.C.) residents, the Government of B.C., or power markets in Alberta. Consequently, the Panel is unable to assess the actual magnitude or extent of this particular effect.

# 5 EFFECTS ON THE ICE REGIME OF THE PEACE RIVER

## 5.1 Impacts of the Project on the Peace River Ice Regime

### 5.1.1 Views of the Applicant

Glacier acknowledged that the Dunvegan project would change the ice regime of the Peace River. It stated that it recognized the need to carefully define any such changes and to scrutinize any impacts on communities in the region.

Glacier told the Panel that it had engaged the most experienced ice expert for the Peace River and employed the most sophisticated models available to quantitatively assess the impacts of the project on the ice regime. It reported that its consultant, Mr. David Andres of Trillium

Engineering Ltd., had developed the TRICEP model specifically for the Peace River in 1988 and had developed an ice lodgement model and a frazil ice transport model to supplement TRICEP. Glacier added that it had used a second model, the RICE model developed at Clarkson University in New York, to simulate the ice regime and to verify the results of the TRICEP model. Glacier explained that both models simulated about a dozen ice processes and sub-processes associated with a river ice regime, and it submitted that the models accurately predicted the advance and recession of ice fronts along the Peace River under different climatic conditions.

Glacier noted that the two "state-of-the-art" models produced different predictions. This occurred, at least in part, because the RICE model assumed that all frazil ice was incorporated into the formation of the ice front whereas the TRICEP model assumed that a portion of the frazil ice was carried downstream and deposited elsewhere. Glacier submitted that, as a result, the two models defined the boundaries for the likely changes in river ice conditions associated with the Dunvegan project.

Glacier described how it used actual ice conditions reported for certain selected winters to represent the full range of temperature conditions: the winter of 1995-1996 was used to represent a very cold winter, 1984-1985 a cold winter, 1992-1993 an average winter, 1997-1998 a warm winter, and 1987-1988 a very warm winter.

Glacier submitted that its models accurately predicted primary consolidation events, "primary consolidation" being defined as the process whereby a juxtaposed ice cover is transformed into a solid ice cover. Glacier noted that the TRICEP predictions of the location of the ice front on 1400 km of river over a five-month winter period correlated well with the actual location of the ice front for each of the representative years, even without having detailed assessments of the hydraulic and geomorphic characteristics of the Peace River. Glacier stated that the modelled location of the ice front on any given day would be less than 40 to 70 km away from its actual location. However, Glacier indicated that there was a 68 per cent probability (one standard deviation) that the estimate was within 25 km of the actual location of the ice front, or a one- to four-day difference from when the model predicted that the ice front would pass a given location on the river. It suggested that the high correlation between model predictions and actual data clearly refuted AENV's assertions that TRICEP made the wrong assessment of ice stability in 20 per cent of the modelled time steps.

Glacier predicted that with the project, pan ice forming upstream of the weir would lodge and consolidate in the headpond, thereby forming a second ice front that would progress farther upstream than under current conditions. It concluded that one consequence of the second ice front would be more frequent ice cover at the Town of Taylor, B.C. Because the weir and headpond would intercept pan ice that would otherwise flow downstream, Glacier also predicted that there would now be more open water downstream of the project. Furthermore, it predicted that the ice front on the lower reach of the river would develop more slowly than at present, resulting in a thicker and therefore more stable ice cover.

Glacier acknowledged that neither the TRICEP nor the RICE model simulated or predicted dynamic ice events such as the secondary consolidations or mechanical breakup events that had caused some of the worst ice-related floods in the Town of Peace River. However, Glacier argued that the TRICEP model could be used to assess whether the conditions that lead to these

dynamic events were likely to occur. Glacier reported having used other models to assess processes such as lodgement of ice behind the proposed dam and the potential for surges.

With respect to the dynamic process of ice lodgement, Glacier submitted that for river flows of up to 1800 $m^3/s$ and assuming no flows through the fish bypass sluices (see Section 6.3), no water would pass over the structure. As a result, ice pans forming upstream would lodge in the headpond, and a solid ice cover would form by juxtaposition and ice thickening against the powerhouse. It explained that the structure would prevent pan ice from moving downstream, which would slow the rate of formation of the ice front below the project and would delay freeze-up at the Town of Peace River. Glacier suggested that the slower rate of ice advance up the river would result in a much more stable ice cover on the river, eliminate the potential for secondary consolidations, and reduce the risk of ice-related flooding during freeze-up.

At river flows above 1800 $m^3/s$, which might occur 10 per cent of the time, Glacier predicted that ice would begin to lodge in the headpond when the concentration of surface ice at the headpond exceeded 10 per cent. It noted that by allowing flows through the fish bypass sluices, the structure could pass flows of up to 2100 $m^3/s$ before water would pass over the structure. However, even if ice pans were to pass over the weir during freeze-up, Glacier determined that this would pose no risk to the Town of Peace River, since the ice front would be forming well downstream at that time. If lodgement in the headpond were to occur when the ice front was above the Town of Peace River, Glacier suggested that the development of the ice cover and the potential risk of ice-related flooding during freeze-up would be no different from that at present. Based on the evidence related to lodgement, Glacier concluded that an ice boom, as suggested by AENV, would not be required since, according to Glacier's analysis, there would be no risk of secondary consolidation caused by ice overtopping the weir.

With respect to secondary consolidations, Glacier suggested that the inability of the models to predict dynamic events posed no difficulty because the Dunvegan project itself would eliminate all of the conditions that might produce a secondary consolidation. It identified these conditions as being a rapid upstream progression of the ice front during cold conditions, followed by a warm spell such as occurred in the winter of 1991/1992 and/or major fluctuations in the releases from the Bennett Dam. It concluded that with regulated flow, the large change in flows that might cause secondary consolidations would not occur. Furthermore, with the project in place, the ice pack downstream would be thicker due to frazil deposition and would provide more stability against sudden increases in flow and/or thermal melting. Glacier predicted that when the ice front passed through the Town of Peace River, the accumulation of frazil ice would be 0.5 to 1.5 m thicker than at present and would increase the base freeze-up level by the same amount.

Glacier reported that it had also undertaken a quantitative analysis of the scenario in which secondary consolidation of the ice front upstream from the weir could release a surge of water that would overtop the weir. If such a surge occurred, it could potentially cause a disturbance to the downstream ice front, possibly resulting in an increased risk of flooding at the Town of Peace River. For this evaluation, it reported using recorded flows for 2000/2001, which it determined to be in the upper range of seriousness. Glacier concluded that such an event would be highly unlikely because the ice cover on the headpond would effectively attenuate a surge in flows. Glacier estimated that if such an event occurred, it would produce only a 5 per cent increase in the discharge at the Town of Peace River. In the opinion of Glacier, this would be insufficient to

destabilize the ice cover at the Town of Peace River, even under conditions such as occurred in 1992 when there was a significant ice consolidation event.

In summary, based on the results of the TRICEP model, Glacier concluded that implementation of the Dunvegan project would result in the following changes to the ice regime of the Peace River:

- more frequent ice cover upstream of the B.C. border;
- open water downstream of the proposed facility;
- a delay in the development of the ice front through the Town of Peace River;
- a reduction in the duration of the ice cover as far downstream as the Town of Peace River, particularly in warmer than average winters;
- thicker ice cover at the Town of Peace River;
- the elimination of secondary consolidations at the Town of Peace River; and
- a slight delay in the thermal recession of the ice front past the Town of Peace River.

Glacier noted that the results of the RICE model, in contrast to the TRICEP model, predicted that the project would result in no meaningful changes in the ice regime of the Peace River.

Glacier submitted that the ice experts for AENV and BC Hydro had provided no evidence to refute the work of Mr. Andres, but noted that both organizations had agreed that Glacier had used the best models available to evaluate project impacts on ice. It observed that Dr. Hicks, on behalf of AENV, had only provided a critique of Glacier's work and simply offered a different professional opinion with respect to the reliability of the models and their results. With respect to the views of Mr. Jasek on behalf of BC Hydro, Glacier concluded that his modelling work merely confirmed the results of the RICE model and that any differing conclusions about changes in the ice regime were based on his professional opinion rather than on quantitative evidence. Glacier observed that the Boards were frequently faced with assessing the results of complex models where there was disagreement among experts. Glacier urged the Panel to rely on the opinions of its expert in this case since Mr. Andres had more extensive experience assessing ice conditions on the Peace River.

With respect to whether models could provide a realistic assessment of the various processes related to the ice regime, Glacier acknowledged that models could not predict future events with absolute certainty and that there would always be some element of risk associated with a proposed project. However, it observed that it had employed the best models, conservative assumptions, and all reasonable means to assess potential impacts on the ice regime and that it was very confident in its assessment of the predicted impacts.

### 5.1.2 Views of the Interveners

Mr. Sawchuk noted that based on his observations as a long-time area resident, ice conditions on the Peace had changed since the Bennett Dam had been in operation. He observed that the ice floes were smaller and thinner than before the dam. He also observed that with the resulting flow regulation, ice that formed along the shore during peak flows often broke away and floated downstream when flows were reduced. He predicted that with the Dunvegan project, ice floes would be broken into smaller pieces as they passed over the weir and that this would reduce downstream ice problems.

Friends of the Peace noted that whenever models were used to simulate potential effects, there was always some degree of uncertainty in the results and that different conclusions could be drawn when limited data were available. In its opinion, there were still some conflicting opinions among the ice experts concerning the potential impacts of the project on the ice regime of the Peace River. It proposed that the only way to increase certainty was to spend more time and money studying ice movements, ice formation, and ice thickness. For these reasons, Friends of the Peace advocated that the Panel delay its decision until there was more certainty.

BC Hydro challenged Glacier with respect to its conclusion that secondary consolidations at the Town of Peace River would be eliminated. It provided evidence with respect to the potential cumulative risk associated with the presence of two ice fronts, one upstream of Dunvegan and the other downstream. It suggested that if a primary or secondary consolidation were to occur at the upstream ice front, the headpond would likely arrest the movement of ice, but the water released by the event could go through or over the project and down the river toward the Town of Peace River. BC Hydro did indicate that it was unsure of the extent to which this release would be attenuated downstream of the project and whether it would be strong enough to trigger a secondary consolidation event at the Town of Peace River. It also acknowledged that Glacier had evaluated such a scenario using the 2001 ice consolidation event, but observed that the 2001 event involved a collapse of about 15 km in length, which caused water levels at the Town of Peace River to surge by about 0.5 m. BC Hydro suggested that Glacier should have instead modelled the 1992 event, which involved an ice collapse about 100 km in length and a surge of about 1.5 m. Overall, BC Hydro submitted that because of lack of knowledge on this issue, it was impossible to conclude that the risk of secondary consolidations would be eliminated post-Dunvegan.

BC Hydro also had some reservations about Glacier's use of the TRICEP model to predict project impacts on the ice regime. It explained that it had much more confidence in the RICE model, which was used operationally elsewhere in North America, so it had collaborated with Glacier in undertaking a separate analysis using the RICE model. According to BC Hydro, the RICE model predicted that the Dunvegan project would have the following effects on the ice regime:

- On average, the first day of ice arrival at the Town of Peace River, the duration of the ice cover, and the date of departure would remain unchanged.
- There would be no reduction in the likelihood of secondary consolidations.
- The ice front upstream of the Town of Peace River would advance to the bottom of the tailrace at Dunvegan.

This last effect, BC Hydro noted, would greatly reduce the project's ability to generate power.

BC Hydro explained that many of the differences between the RICE and TRICEP model results were based on different assumptions regarding the treatment of suspended frazil ice. It recommended that in comparing the model results, the most conservative results should be preferred. For that reason, BC Hydro noted that its assessment of potential project impacts was based on the most conservative impacts drawn from its use of the RICE model and Glacier's analyses using TRICEP.

The Town of Peace River commended Glacier for its efforts, knowledge, and professionalism in modelling and assessing the potential impacts of the Dunvegan project on the ice regime of the Peace River. However, it professed that it was unable to place much confidence in the results of Glacier's work. In its opinion, ice formation and recession processes were too complicated to predict with the degree of certainty that it would need to be convinced that the Dunvegan project would not jeopardize the Town of Peace River or its residents. The Town of Peace River stated that, despite the ability of the model to predict the location of the ice front within 25 km 68 per cent of the time, it was greatly concerned about the potential uncertainty during the other 32 per cent of the time. Since the Town of Peace River did not believe that it had the expertise to understand the technical details of the modelling, it said it would rely on AENV to determine the reliability of Glacier's evidence.

The Town of Peace River observed that none of the ice experts involved in the review seemed to be in agreement concerning the likely impacts of the Dunvegan project. It noted that the original analyses and expert opinion had concluded that the project would have a severe impact on the ice regime, while the most recent modelling work predicted no impact whatsoever. Further, it noted that neither of the models used by Glacier would have predicted the dynamic breakup events that occurred in 1991/1992 and 1996/1997. Overall, it admitted to being very reluctant to accept the results of models that predicted different outcomes and were unable to reproduce actual historic events.

The Town of Peace River indicated that based on the additional evidence provided during the hearing, its reservations about the adequacy of the modelling techniques remained. It was particularly concerned that although Glacier's experts concluded that there would be no secondary consolidation events with the project in place, it also understood that the other experts had suggested that such events might occur under some extremely rare circumstances and that available models could not predict secondary consolidation events.

AENV reported that because of their complexity, it is very difficult to accurately predict ice processes. It provided evidence concerning the numerous factors that could affect freeze-up and breakup processes and commented on the current state of knowledge concerning these factors. It explained that while models had been developed to predict the gradual upstream and downstream progression of an ice front due to factors such as air temperature, water temperature, and flow velocity, river freeze-up and breakup also involved dynamic processes that were very difficult to observe, measure, or model. AENV observed that dynamic processes involving the collapse of an ice front during freeze-up or a sudden breakup could occur in a very short time (minutes or hours) and lead to ice jams that could restrict river flows and cause flooding. It noted that sudden changes in river flows, such as the operations of hydroelectric power facilities, could trigger these dynamic events.

AENV described the TRICEP and RICE models used to simulate freeze-up and breakup processes on the Peace River as empirical models, based on perceived cause-effect relationships, rather than deterministic models, which require clear and detailed understanding of the complex physical laws involved in the formation and decomposition of an ice sheet on a river. AENV noted that the models included numerous parameters and therefore required large amounts of data.

While AENV was of the opinion that the modelling done by Glacier reflected the current state of knowledge, it raised several concerns about the adequacy of the models and their predictions with respect to ice processes. It noted that there had only been limited statistical attempts to model ice consolidation events based on a limited number of observations. It also noted that there were as yet no reliable models of dynamic breakup events, because it was nearly impossible to measure key parameters during a breakup event due to safety and logistical concerns.

AENV suggested that the only way to determine the adequacy of the models used by Glacier was to examine how well they simulated actual ice conditions in past years. With respect to how well the TRICEP model was able to accurately predict the location of the ice front, AENV observed that the divergence between the model and the historical record was, at worst, about 7 to 10 days, but submitted that if the error in the model calibration was that large, it was unlikely that the predictions for the Dunvegan project would be any more reliable. It also noted that neither the TRICEP nor the RICE model was capable of predicting dynamic events. Furthermore, AENV noted that scientists had never documented the consolidation process, and it disagreed with Glacier's assessment that the Dunvegan project would eliminate secondary consolidations, which sometimes caused ice jams and flooding at the Town of Peace River. It observed that interpretation of model results required some degree of professional judgement and reported that its expert did not share Glacier's confidence or convictions regarding the conclusions of its ice analyses.

Dr. Hicks, on behalf of AENV, stated that she had concluded that Glacier's modelling of ice effects reflected the best science available at the present time. However, she added that interpretation of the model results and the associated implications involved considerable judgement on behalf of the consultants. Dr. Hicks indicated that, based on her knowledge of ice processes and the models used, she reached different conclusions about the potential impacts of the project and was not convinced that it would not increase the risk of flooding at the Town of Peace River.

### 5.1.3 Views of the Panel

The Panel accepts that Glacier employed the best available models to predict the impacts of the Dunvegan project on the ice regime of the Peace River. It appreciates hearing the views of the parties concerning the accuracy and reliability of the model predictions and values the evidence and professional opinions provided by the three ice experts. The Panel believes it now understands the potential strengths and weaknesses of the two empirical models, TRICEP and RICE, as tools to predict the advance and recession of ice fronts on the Peace River.

Having reviewed the model results, the Panel is struck by the very different predictions of ice effects immediately below the proposed structure. The RICE model predicted that the ice front upstream of the Town of Peace River would advance to the bottom of the tailrace at Dunvegan, which, in turn, would potentially reduce the project's ability to generate power. In contrast, the TRICEP model predicted that there would be open water below the proposed dam for as far as 30 km downstream in a very cold year and even farther in warmer years. The Panel believes these differences are not trivial. If the Panel were to adopt the predictions of the TRICEP model on this point, it would have to be concerned with the potential impacts of open water on the Shaftesbury crossing (see Section 5.4). If the Panel were instead to adopt the predictions of the

RICE model, that concern would vanish, only to be replaced by concern that ice forming at the tailrace could interfere with power generation for most of the winter and would reduce the potential utility of the project (see Section 4).

Since the evidentiary record from the hearing does not contain an examination of the differing assumptions between the two models concerning the behaviour of frazil ice, the Panel has no basis to evaluate the predictive capabilities of one model over the other. It can only conclude that there can be considerable uncertainty in attempting to simulate even the best-understood ice processes, namely primary consolidation and thermal recession. The Panel must therefore have regard for the potential impacts predicted or implied by both models.

The Panel is also concerned by evidence stating that neither secondary consolidations nor other dynamic ice events, which represent crucial risks, are capable of being modelled and that neither the TRICEP nor the RICE model would have been able to predict the actual 1992 and 1997 flood events.

Therefore, the Panel believes that in this situation, the assessments of risk and uncertainty provided at the hearing must be weighed carefully.

### 5.2 Impacts on Flooding at the Town of Peace River

#### 5.2.1 Views of the Applicant

Glacier provided an overview of the ice processes that have resulted in previous flooding of the Town of Peace River. It noted that although neither the TRICEP model nor the RICE model was designed to assess the risk of flooding at the Town of Peace River, both could be used to predict changes in the frequency of ice conditions known to be associated with risks of secondary consolidation and ice jams instigated by mechanical breakups. Glacier therefore investigated the project's impacts on ice thickness, secondary consolidations during freeze-up, and the timing of the recession of the ice front on the Peace River in relation to the breakup of the Smoky River. It also assessed opportunities for mitigating any adverse effects through flow regulation and other means.

Glacier stated that during freeze-up, there was a risk of flooding due to secondary consolidations when the ice front upstream of the Town of Peace River collapsed due to changes in river flow or weakening of the ice as a result of melting. Glacier commented that such events had occurred in 1982 and 1992, when surges of water and ice moving downstream caused the river at the Town of Peace River to rise by as much as 5 m above the base freeze-up level. Glacier reported that although it was impossible to prevent such secondary consolidations, the Joint Task Force on Peace River Ice (JTF) had implemented a strategy to reduce the risk. It explained that the strategy employed over the last 20 years was to lower the base freeze-up level on the river at the Town of Peace River by limiting releases from the Bennett Dam to 1500 $m^3/s$ for the one- to four-week period when the advancing ice front was located between Peace River and Dunvegan.

Using the TRICEP model, Glacier predicted that with the project there would always be an ice front between Dunvegan and the Town of Peace River, because an ice cover would never develop for a distance of about 30 km downstream from the structure, even in very cold winters. It also predicted that the rate at which the ice front moved up the river would be slowed to the

extent that formation of the ice cover at the Town of Peace River would be delayed by about two weeks in normal or warmer than normal winters. With the location of the ice front being more stable over a longer period of time, Glacier reported that TRICEP predicted that the resulting ice cover would be thicker and stronger.

According to Glacier, the formation of a thicker and stronger ice front would virtually eliminate the possibility of secondary consolidation events from occurring during the freeze-up period. Thus, it concluded that the project would benefit the Town of Peace River by reducing the potential flood risk associated with secondary consolidation. It stated that it had confirmed this by empirically modelling the effects of an upstream secondary consolidation event with the project using the actual flow records leading up to the 2000/2001 event. In the opinion of Glacier, this event was "toward the top end of the range of seriousness" and, had the project been in place, it predicted that the flow surge would have been attenuated under the ice cover such that the ice cover at the Town of Peace River would not have destabilized, as it did in 2001.

Glacier did acknowledge that when it used the RICE model, the results suggested that formation of the ice front would not slow until upstream of the Town of Peace River, so that the predicted ice cover would not be as thick or as strong as predicted by TRICEP. However, the RICE model also showed no difference in the susceptibility of this reach to secondary consolidations, so Glacier was able to conclude that, at worst, the Dunvegan project would not increase the risk of a secondary consolidation event causing flooding at the Town of Peace River.

Glacier reported that the risk of spring flooding at the Town of Peace River was dependent on the relative timing of breakup for the Peace River and its tributary, the Smoky River. It indicated that ice jamming was not a problem when the Smoky River breakup occurred after the Peace River ice front had receded well downstream of the confluence of the two rivers (thermal breakup). However, in years when Smoky breakup occurred when the ice cover remained at or near the confluence (mechanical breakup), ice jams did occur, sometimes resulting in flooding at the Town of Peace River. Glacier noted that BC Hydro could be asked to reduce its discharge from the Bennett Dam under these conditions to provide more freeboard for the dikes and hence greater protection for the Town of Peace River. Glacier submitted that such flow controls during breakup were required on average once in 10 years.

Glacier noted that the TRICEP model predicted a delay in the thermal breakup at the Town of Peace River of four to eleven days during cold and very cold winters. In these years, there would be a higher risk that the Smoky River would break up into an intact ice cover on the Peace River (i.e., mechanical breakup). For normal and warmer than normal years, Glacier concluded that there would no change in the risk of flooding during breakup because the dates at which breakup was predicted to occur would not change.

Glacier stated that it undertook two additional analyses to assess the potential impact of its project on the risk of flooding at the Town of Peace River. First, it conducted a review of historical (post-Bennett) severe ice events, estimated the probable effects of the project (using TRICEP), reconstructed the historical records to incorporate the effects of the project, and then compared the results. According to Glacier, the results of its historical assessment suggested that although the Dunvegan project would have raised water levels for most ordinary freeze-up and breakup events, it would not have affected water levels for larger events with a return frequency

of one in 5 years. With these results, Glacier concluded that the project would not increase the annual risk of the water levels overtopping the dikes at the Town of Peace River.

The second approach used by Glacier to assess the risk of flooding at the Town of Peace River was a stochastic Monte Carlo simulation in which the probability of a flood event was postulated to be a function of the independent or conditional probabilities of the events that could lead to flooding. Glacier submitted that the results of the Monte Carlo analysis showed that for significant breakup or freeze-up events where water levels would come within 2 m of the top of the dikes, the project would not significantly affect the severity of these events. For events with a return frequency of one in 5 years, the analysis predicted that there would virtually be no difference in peak ice-related water levels on the Peace River, even when a mechanical breakup occurred. Glacier stated that it had had the results of the Monte Carlo simulation evaluated by an external expert and subsequently undertook further statistical analysis to ensure that the randomness and homogeneity of the data were suitable for analysis using this technique. Overall, Glacier concluded from the Monte Carlo simulation that even with an increased probability of mechanical breakup, there would be no increase in the risk of flooding at the Town of Peace River during breakup.

In comparing the results of the historical and Monte Carlo analyses, Glacier indicated that both used outputs from the TRICEP model and evaluated worst-case scenarios, but it considered the historical analysis to be more representative because it was based on actual historical flood events. For this reason, Glacier concluded that, overall, the Dunvegan project would decrease the risk of flooding at the Town of Peace River. It explained that this conclusion was based on its assessment that the project would reduce the likelihood of flooding during freeze-up and that this would more than offset the neutral or slight increase in flood risk that might occur during spring breakup. Glacier did agree that although both freeze-up and breakup events currently represented a significant risk to the Town of Peace River and could overtop the dikes, historically breakup events had occurred more frequently.

Glacier stated that it had originally believed that the control flows currently provided by BC Hydro would have to be extended in order to limit the risk of secondary consolidation events during freeze-up. However, after further analysis, it concluded that because the slower development of the ice front would create a stronger, more consolidated ice front near the Town of Peace River, the risk of secondary consolidation would virtually be eliminated. Accordingly, Glacier indicated that BC Hydro would not have to extend the duration of control flows.

Glacier noted that the JTF would have to adopt new criteria when flow regulation was required. At present, the JTF requires BC Hydro to maintain controlled flows for the period of time during which the ice front is located between Dunvegan and the Town of Peace River plus another 10 to 14 days for the ice to strengthen. Glacier indicated that under the existing regime, the overall duration of flow controls was between 20 to 75 days, with 36 days being the historic average. With the Dunvegan project, it noted that since the ice front would now never reach Dunvegan, there would always be open water downstream.

As an alternative, Glacier suggested that the JTF adopt a criterion based on ice strength and thickness at the Town of Peace River. Glacier proposed that a critical ice thickness of 0.4 m would be adequate to prevent secondary consolidation events. It submitted that a criterion based on critical ice thickness at the Town of Peace River would be easier to implement, provide it

with a greater degree of protection, and reduce the need for controlled flow to between 10 and 30 days. Glacier committed to working with the JTF to develop this criterion and to participate in the ongoing management of ice issues if the Dunvegan project were approved. It also committed to compensating the Town of Peace River for the increased costs of maintaining its ice watch crews for the longer period of time that would be required for the ice front to recede through the town.

With respect to breakup events, Glacier noted that currently there were procedures in place for mitigating the potential for flooding at the Town of Peace River. It explained that BC Hydro was periodically asked to reduce discharges from the Bennett Dam to provide more freeboard for the dikes at the Town of Peace River. Glacier said it expected that with Dunvegan, BC Hydro might be called upon to reduce flows more frequently because higher freeze-up levels resulting from the project would reduce the available freeboard. It noted that BC Hydro had testified that flow regulation to address breakup events would potentially be required once every 5 years, compared to once in 10 years at present. However, Glacier submitted that its project would have no net adverse impacts on BC Hydro's operations because the shorter duration of freeze-up control flows under Glacier's proposed ice thickness and strength criterion would more than compensate for more frequent control flows during breakup. Based on its assessment, Glacier predicted that BC Hydro would actually benefit from the implementation of the Dunvegan project.

Notwithstanding its favourable assessment of the impact of its project on BC Hydro, Glacier submitted that BC Hydro should not be entitled to any compensation for any changes in river regulation that might affect its power generation because the Peace River should be considered a shared resource relied upon by a number of users, including industry, municipalities, government, and the public.

Another type of mitigation assessed by Glacier was the creation of a physical structure upstream of the Town of Peace River that could serve as an ice boom. For example, it stated that it had investigated developing a structure similar to the Dunvegan project that would be located in the vicinity of Shaftesbury. However, it had eventually determined that it would not pursue the development of such a structure in the near future.

Glacier stated that it had also concluded that an ice boom in the headpond above the proposed weir would not be required to mitigate project impacts. It concluded that since the structure could accommodate flows of 2100 $m^3/s$, which exceeded normal winter flows, almost all ice would lodge above the structure and, therefore, an ice boom would not provide any additional protection.

As another approach to addressing concerns about project effects on flooding at the Town of Peace River, Glacier committed to acquiring third-party liability insurance to cover any liabilities that might be associated with project impacts on the Peace River ice regime. It indicated that although it had determined that such insurance was readily available, it had not decided what level of coverage would be required. Glacier added that it would also prepare an emergency response plan were the Panel to approve the project.

### 5.2.2 Views of the Interveners

Based on its assessment, BC Hydro stated that it had concluded that the Dunvegan project posed three risks: an increased risk of secondary consolidations that might result in flooding at the Town of Peace River; an increased risk of the Smoky River breaking up into an intact ice cover on the Peace River; and the cumulative risks associated with two ice fronts. It observed that Glacier had acknowledged that it was unable to mitigate these impacts and that it would be relying on BC Hydro to mitigate flood risk through flow regulation in accordance with the recommendations of the JTF. While BC Hydro indicated that it was not opposed to the Dunvegan project, it submitted that the Panel needed to understand how BC Hydro's operations would be affected before the Panel could determine whether the project was in the public interest.

BC Hydro stated that when required, it managed flows from its two hydroelectric facilities on the Peace River to reduce flood risk at the Town of Peace River in accordance with direction from the JTF. BC Hydro submitted evidence showing that for each day it was required to operate its facilities under ice control flows, it lost about 580 MW of heavy load hour generating capacity, or about 9.3 GWh/d. BC Hydro submitted that Glacier's proposal for flow control during freeze-up based on ice thickness showed promise as a more consistent means of stabilizing ice in the Peace River without compromising the safety of the Town of Peace River while reducing the duration of flow controls. It noted that it would pursue adopting this type of flow control criterion with some refinements regardless of whether the Dunvegan project was approved and proposed a three-year study to determine how quickly ice thickness and ice strength increased under various air temperatures and insulating snow cover. BC Hydro added that were the current flow control regime to be maintained, it would be opposed to the Dunvegan project because it could be required to implement flow controls for the entire winter period as a result of predicted changes in the ice regime.

With respect to flooding problems during breakup, BC Hydro stated that it accepted Glacier's analysis that the proposed project would increase the risk of the Smoky River breaking up into an intact Peace River. However, it noted that BC Hydro currently managed that threat by reducing the flows in the Peace River to offset increasing discharges of the Smoky River in order to maintain the freeboard of the dikes at the Town of Peace River. BC Hydro reported that spring flow controls were implemented when there was a high snowpack in the Smoky River basin, discharges at the Town of Peace River were predicted to be above 3200 $m^3/s$, and it appeared likely that the Smoky River would break up in advance of the Peace River. It confirmed that these spring flow controls were currently required about one year in ten and acknowledged that even though the requirements for such controls could double as a result of the Dunvegan project (one year in five), it was still willing to manage its operations to minimize the risk of flooding at the Town of Peace River.

Overall, BC Hydro stated that it was neither supporting nor opposing the proposed project but it did have some general concerns about any demands that may be placed on it to modify its operations in an attempt to mitigate or prevent some of the ice-related impacts associated with the Dunvegan project. However, it was unable to support Glacier's contention that flood risks at the Town of Peace River would be potentially reduced as a result of the construction and operation of the Dunvegan project.

Mr. Doll stated that, in his opinion, creation of the Bennett Dam had provided a means of controlling high water levels on the Peace River and this in turn had decreased the chance of flooding at the Town of Peace River. He submitted that since the Dunvegan project would not affect river flows, there should be no impact on the ice regime or the associated risk of flooding.

The Town of Peace River stated that 75 per cent of its 6536 residents resided in areas that had been affected by flood events and could be subjected to increased flood risk as a result of the Dunvegan project. It noted that many of the local businesses were also located in that same part of the Town and added that some of those businesses affected by the last flood had ceased operating, leading to concerns about the very future of the community.

In terms of current flood risks, it reported that the total cost of the 1997 flood was not known but it noted that some town businesses had received about $8 million in an out-of-court settlement with the Town of Peace River and AENV. It submitted that the cost of damages was probably twice as high when disaster assistance funding from federal and provincial governments was included. The Town of Peace River explained that local residents and businesses initially paid cleanup and damage costs and then sought compensation from provincial and federal governments. The Town of Peace River noted that BC Hydro had also provided some assistance with the cleanup, but explained that this was done as a good neighbour, not as a responsible party.

The Town of Peace River reported that damage from the 1997 flood had occurred because not all the dikes along the Peace River had been constructed to accommodate a 1:100 year flood event. It noted that all dikes had since been upgraded to the 1:100 year standard. In regard to the controlled flows implemented by BC Hydro during freeze-up and breakup under the direction of the JTF, the Town of Peace River acknowledged that this had also helped protect against ice jam flooding.

The Town of Peace River stated that it was very concerned that the predicted delay in the recession of the ice front through the town would increase the risk of flooding during breakup because there would also be an increased risk of the Smoky River breaking up into an intact Peace River cover. It observed that since the models used by Glacier would not have been able to predict recent dynamic flood events, it had little confidence in Glacier's conclusion that the Dunvegan project would in fact result in a net decrease in the risk of flooding. Furthermore, it noted that if the Dunvegan project were to increase water freeze-up levels by 1 to 2 m, as predicted by Glacier, the freeboard or safety margins provided by the dikes would be reduced by nearly half. In its assessment, this loss of freeboard would double the risk of a flood event from one in 10 years to one in 5 years.

The Town of Peace River said that it was also concerned about potential increases in flooding due to secondary consolidation. It noted that although Glacier had concluded that ice thickness of 0.4 m would be sufficient to resist secondary consolidation events, pictures taken during actual flood events often showed ice chunks exceeding 1 m in thickness.

The Town of Peace River also raised the question of responsibility for damages were a flood event to occur. It noted that Glacier had repeatedly stated that the Dunvegan project would not affect the ice regime but had offered to acquire liability insurance as added protection. However, it further noted that before an insurance claim would be paid, liability would have to be proven.

The Town of Peace River suggested that should such an event occur, it expected that Glacier would use the results of its analysis to demonstrate that the Dunvegan project was not at fault. Furthermore, it suggested that BC Hydro could also deny liability by blaming the cause of the flood on the Dunvegan project, which would be located downstream from its operations. As a result, the Town of Peace River was concerned that if the project were approved, liability and accountability for damages resulting from future floods would be lost. It submitted that part of its concern could be addressed by having Glacier post a bond that could be accessed without having to prove cause or liability.

The Town of Peace River noted that even if delayed recession and freeze-up of the ice did not increase the risk of flooding, such conditions would create other costs. It noted that its emergency response plan required that crews be placed on ice watch during freeze-up and breakup and that this costs about $50 000 per year. It suggested that if the duration of these events were to increase, Glacier should be required to compensate it for the incremental costs of maintaining crews for longer periods.

The Town of Peace River concluded that despite the technical information that had been presented by Glacier, it was impossible to conclude "beyond all reasonable doubt" that the Town of Peace River would not be negatively affected by changes to the ice regime of the Peace River as a result of the Dunvegan project. It reminded the Panel that past flooding events in the town had cost many millions of dollars, caused business closures, and impacted many people. It also noted that the Town of Peace River and the province had spent several million dollars to build dikes to prevent such events. For this reason, it indicated that it was hesitant to accept "speculative estimates" of the impacts that the project would have upon the Town of Peace River, especially when there was not unanimous agreement on the nature of these impacts. It observed that the only "arm's-length" ice expert at the hearing noted that current modelling techniques could not provide accurate predictions of potential changes in the ice regime. The Town of Peace River suggested that in making a decision to approve the project, the Panel must be absolutely convinced that the level of safety of town residents would not be compromised or even potentially compromised. It remarked that AENV testified that it could not provide such an assurance. Consequently, it was the opinion of the Town of Peace River that the Dunvegan project would increase its risk of flooding.

AENV indicated that it too had some concerns regarding how changes in the ice regime resulting from the Dunvegan project might affect the Town of Peace River. With respect to impacts during freeze-up, AENV disagreed with Glacier's conclusion that the formation of a thicker and stronger ice front downstream from the project would virtually eliminate the possibility of secondary consolidation that might cause flooding at the Town of Peace River. AENV noted that ice consolidation events had not been well studied and, based on the limited information available, it could not conclude that secondary consolidations would be eliminated. It suggested that a sudden change in flow conditions causing a surge wave might trigger a secondary consolidation event. Furthermore, AENV also observed that with Dunvegan, freeze-up levels at the Town of Peace River would be higher and, with less available freeboard at the dikes, smaller ice jam events might lead to flooding. AENV acknowledged that it had not yet evaluated Glacier's proposal for regulating flows during freeze-up on the basis of critical ice thickness at the Town of Peace River, but suggested that the JTF would be doing so in the future.

AENV noted that one of its concerns relating to secondary consolidation was Glacier's assumption that the ice pans formed above the weir would lodge in the headpond. It did agree, however, that since the structure had the capacity to accommodate flows of up to 2100 $m^3/s$, the probability of ice spilling over the structure would be significantly reduced. AENV indicated that as part of its review under the Water Act, it would re-evaluate the need for an ice boom to ensure ice lodgement.

AENV stated that its greatest concern about project impacts related to the potential for delayed breakup of the Peace River at the Town of Peace River and whether this might lead to more frequent spring flooding. It provided evidence showing that in the period from 1971 to 1999, the Smoky River breakup at Watino (65 km upstream from the confluence with the Peace River) had occurred prior to ice on the Peace River receding below the Town of Peace River in 22 or 23 of 29 years. It observed that although such events did not always lead to dynamic breakup events on the Peace River, there was typically a very narrow window of time between breakup on the Smoky and ice recession below the Town of Peace River. Based on this narrow window, AENV expressed concern that any additional delays in ice recession at the Town of Peace River, as predicted by Glacier for colder than average years, would significantly increase the likelihood of a dynamic breakup and ice jams on the Peace River. It submitted that although Glacier's evidence was that in average years the ice cover on the Peace would leave the Town of Peace River before Smoky River breakup, it also remained concerned about this conclusion because of the width of the confidence interval (i.e., uncertainty) in the TRICEP model's predictions of the location of the ice front.

AENV stated that it had accepted the evidence of Glacier and BC Hydro that by reducing flows from the Bennett Dam immediately prior to the Smoky River breakup, some of the risk of dynamic breakup on the Peace River could be alleviated. However, it noted that this could only occur in situations where water managers had sufficient advance warning to be able to reduce flows on the Peace River in time to have an effect on water/ice levels at the Town of Peace River, 360 km downstream. It noted that it took about three to four days for releases by BC Hydro to reach the Town of Peace River. AENV suggested that the effectiveness of these measures relied on the ability of water managers to correctly assess the conditions leading up to a dynamic breakup of the Smoky River and noted that Glacier had predicted that with the project in place, water managers would be required to make this assessment twice as frequently (one year in five) as presently required.

### 5.2.3 Views of the Panel

Of all the potential impacts of the proposed Dunvegan project, the Panel believes that the potential for the project to alter the risk of ice-related flooding at the Town of Peace River is the most serious. The evidence of the Town of Peace River concerning the financial and human costs of past floods is a compelling and sobering reminder of the potential severity of these events and the lasting impact that such a disaster can have on a community. The Panel understands that a decision to approve the Dunvegan project would be a decision to accept some change in the risks faced by the Town of Peace River. It has therefore weighed the evidence on this matter with care.

Glacier submitted that the project would eliminate the risk of ice-related flooding due to secondary consolidations during freeze-up, but would slightly increase the risk of ice jams due to mechanical breakups in the spring. Glacier asserted that there would be a net benefit to this

tradeoff because the overall risk to the Town of Peace River would be lowered. The Panel has a number of observations with respect to Glacier's evidence on the two sources of risk and its argument for a net benefit.

With respect to Glacier's assertion that secondary consolidations would be eliminated if its project were built, the Panel observes that this conclusion is only supportable if the TRICEP model's treatment of frazil adhesion to the ice front is correct and the RICE model's treatment is incorrect. The Panel understands that the slower ice front formation predicted by TRICEP could produce stronger ice that could resist secondary consolidation. It also understands, however, that the RICE model, which treats frazil adhesion differently, produces a strikingly different outcome, with more rapid upstream formation of the front and no corresponding strengthening of the ice relative to current conditions that would confer greater resistance to secondary consolidations.

Earlier (Section 5.1), the Panel stated that it has no basis upon which to prefer the results of one river ice model over the other and that it would therefore have regard for the impacts predicted or implied by either model. This approach, the Panel believes, is consistent with Glacier's own evidence that the results of the two models define the boundaries for the likely changes in ice conditions associated with the Dunvegan project. With this in mind, the Panel finds no compelling reason to accept Glacier's assertion that secondary consolidations would be eliminated over the alternative of the RICE model's prediction that there would be no change in the risk of secondary consolidations.

The Panel understands that Glacier's conclusion that secondary consolidations would not occur was based on its assessment that the thickened ice would be sufficiently strong to withstand foreseeable disturbances. In this regard, the Panel notes BC Hydro's observation that the 1992 event, which entailed an ice collapse of 100 km and produced a surge of approximately 1.5 m, was substantially greater than the 15 km collapse and 0.5 m surge of the 2001 event that Glacier modelled in reaching its conclusion that the ice would hold. In light of this evidence that there have been historic disturbances of greater magnitude than the modelled scenario, the Panel cannot be confident that the post-Dunvegan ice would resist secondary consolidation in all cases. A further source of uncertainty raised by BC Hydro is the largely unexplored effect of multiple ice fronts and the prospect that a disturbance in the upstream front could be propagated to the downstream front. The Panel believes the frequency, magnitude, and consequences of such events remain at best uncertain.

The Panel also notes the concern expressed by AENV and the Town of Peace River that due to the anticipated higher freeze-up level and corresponding reduction in the freeboard on the Town's dikes, the consequences of a secondary consolidation could in fact be more severe with the project in place. With these considerations in mind, the Panel cannot rule out the possibility that the project would create conditions resulting in less frequent but more severe flooding due to secondary consolidations. With this level of uncertainty, the Panel cannot be confident that the project's impacts on risks to the Town of Peace River from secondary consolidations are well understood.

The Panel also has concerns with regard to Glacier's predictions concerning the risks of flooding during spring breakup. In considering the potential effect of the project on flood risks associated with a mechanical breakup, the Panel notes that Glacier's analysis predicted a 4- to 11-day delay

in the recession of the ice front past the Town of Peace River for colder than normal winters. Furthermore, the Panel appreciates that the error implicit in the model estimates could extend the predicted effect for an even longer period.

The Panel also notes Glacier's own evidence with regard to the risks associated with a mechanical breakup. In its March 2002 *Reply to the Supplemental Information Request*, Glacier took the position that there would be a thinner ice cover near the Town of Peace River and that this would offset to some degree the higher risk of flooding posed by delays in the thermal breakup of the Peace River. In its reply argument at the hearing, however, Glacier claimed that, with the project in place, a slower progression of the ice front past the Town of Peace River during freeze-up would produce a thicker, stronger ice cover that would better resist mechanical breakup. In the Panel's view the evidence does not reconcile the reasons for these different assessments or indicate whether the recent analysis replaced older information. With respect to this issue, the Panel believes it is unable to conclude with confidence that flooding risks at breakup might be reduced or ameliorated by either thinner or thicker ice conditions.

The Panel also believes that BC Hydro, although willing to implement additional flow controls at the request of the JTF to reduce the risk of mechanical breakup, has only a limited opportunity to mitigate the severity of these effects due to the distance and travel time between the Bennett Dam and the Town of Peace River. The Panel is also concerned that the technically difficult assessment of the risk of the Smoky River breaking up into an intact Peace River ice cover would also now have to be made twice as often—one year in five on average—as a consequence of the proposed project. As noted earlier, even a single error in this assessment of relative risk could have very significant negative consequences for the Town of Peace River.

## 5.3 Impacts on Seepage Flooding and Storm Water Outfalls

### 5.3.1 Views of the Applicant

Glacier noted that the TRICEP model predicted an increase in ice thickness as the ice front built, with the result that water levels at the Town of Peace River may be increased by 1 or 2 m. It determined that a potential consequence of the higher levels might be an increased risk of seepage into the basements of residences situated in the Lower West Peace district, although it said the risk would be quite low. In contrast, Glacier noted that the RICE model predicted that no change in water levels at the Town of Peace River would occur as a result of the project.

Glacier committed to mitigate seepage if it occurred as a result of the project. It reported that it had commissioned an engineering study to identify and evaluate possible mitigation options and, based on work to date, the most viable method appeared to be the construction of a full or partial cutoff wall along the edge of the Lower West Peace district, possibly with pumping of groundwater from behind the wall.

Glacier stated that a second concern arising from higher water levels would be an increased risk of back flooding into the town's storm water outfalls. Although some back flooding already occurs, Glacier suggested that changes to the ice regime might result in some short-term flooding of three to five additional storm water outfalls. It claimed that the impacts would be short-term and could be easily mitigated. Glacier committed to install gates on the additional outfalls that could be affected and, if required, to provide additional pumping infrastructure.

### 5.3.2 Views of the Interveners

The Town of Peace River noted that high water levels over extended periods could cause water infiltration into some of the residences, sewer and storm sewer vaults in the Lower West Peace district. It also described its concerns about higher water levels interfering with the functioning of storm water outfall lines, such that water from major precipitation or melt events would be trapped inside the dikes, causing flooding from within. It noted that Glacier was aware of these concerns and had asked the Town of Peace River for information on the elevation of the outlet structures. It also acknowledged that Glacier had indicated that it was prepared to mitigate these problems. However, the Town of Peace River stated that it had not yet been provided with the results of Glacier's engineering studies on these issues or Glacier's recommendations regarding what mitigation would be most effective. It asked the Panel to ensure that this issue be resolved to the satisfaction of the Town of Peace River before allowing Glacier to proceed with the project.

The Town of Peace River also noted that with higher water levels over extended periods, the integrity of its system of dikes might be eroded or compromised. While it was unsure whether such impacts could occur, it noted that it had not received any assurances that this would not happen.

AENV indicated that it also had concerns about whether changes in the ice regime might result in groundwater seepage flooding in parts of the Town of Peace River. However, it noted Glacier's commitment to resolve these concerns. AENV said it would review Glacier's test data and recommended mitigation measures when that information became available. Furthermore, AENV indicated that it would be considering groundwater seepage mitigation measures as part of its subsequent regulatory process, should the project receive approval from the Panel.

### 5.3.3 Views of the Panel

The Panel believes that increased water infiltration into the some of the residences, sewer and storm sewer vaults in the Lower West Peace district could occur as a result of the Dunvegan project. It notes that Glacier has acknowledged these potential impacts and has undertaken preliminary engineering studies to address these concerns. Were the Panel to approve the project, it would require Glacier to enter into an agreement with the Town of Peace River to address these concerns.

## 5.4 Impacts on the Shaftesbury Crossing

### 5.4.1 Views of the Applicant

Glacier stated that its analyses using the RICE model predicted that there would be no changes to the ice regime, while the TRICEP model indicated that open water could extend 30 to 80 km downstream from the project, depending on the severity of the winter. Glacier predicted that for very warm winters the ice front would not advance far enough upstream for an ice bridge to be constructed at Shaftesbury (see Figure 3); in normal and warmer than normal winters the proximity of the ice front to the Shaftesbury site might prevent construction of an ice bridge; and for colder than normal years, it would be possible to construct an ice bridge. Glacier estimated that in one of 10 years, the ice front with the project in place would not reach far enough upstream to allow construction of the ice bridge and delays in ice formation in the remaining

years would delay development of an ice bridge by about 10 to 15 days. However, it suggested that post-Dunvegan conditions would not be significantly different from those at present, noting that an engineered ice bridge could not be constructed at Shaftesbury in the winter of 2000/2001, which it classified as a warm year.

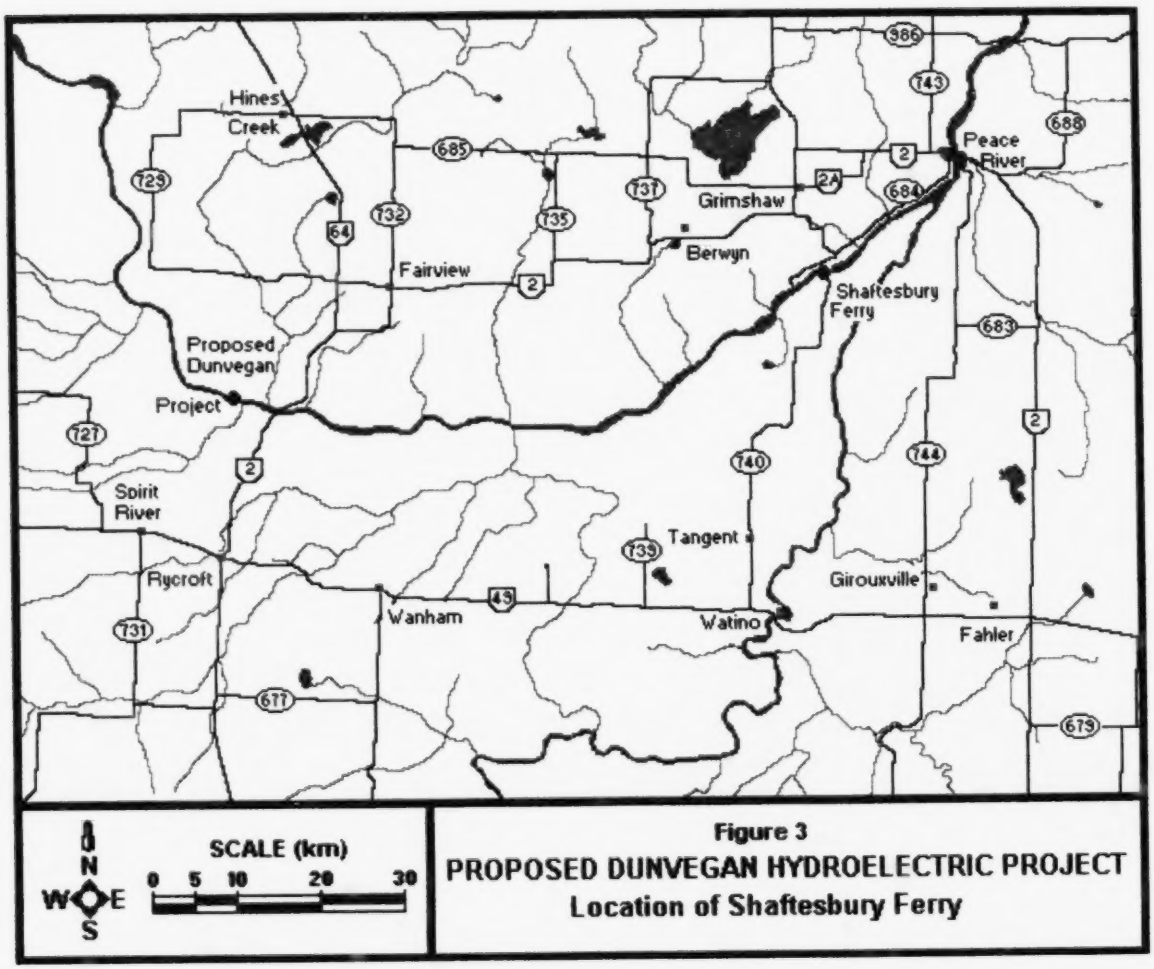



**Figure 3**
**PROPOSED DUNVEGAN HYDROELECTRIC PROJECT**
**Location of Shaftesbury Ferry**

In carrying out its assessment, Glacier stated that it had consulted with the operator of the Shaftesbury ferry and with Alberta Transportation to better understand the current situation regarding both the ferry operation and the construction of the ice bridge. Based on those discussions, Glacier stated that it understood that the ferry and docking system were usually removed from the river about the first week of December, although the actual date depended on ice conditions. It also noted that although this had previously been a municipal government responsibility and the local residents had constructed and maintained the ice bridge, Alberta Transportation had assumed responsibility for the operation and use of the ice bridge for the last two years. Glacier submitted that Alberta Transportation had indicated that it had no concerns about project impacts on the Shaftesbury crossing.

Glacier argued that although the TRICEP model predicted that there would be a reduction in the ice cover on the river at the Shaftesbury site, the resulting impacts on the river crossing would

not be significant. It proposed that the ability to construct an engineered ice bridge at the site would not be different from that at present, but acknowledged that there could be a reduction in the length of the season that an ice bridge would be safe to use. However, it argued that with less ice cover on the river, the operating season for the ferry would increase and this would offset any reduction in the availability of the ice bridge.

Glacier also suggested that the impacts of possible changes in the availability of the ice bridge and ferry on people crossing the river at the Shaftesbury site would not be as significant as portrayed by local interveners. It submitted that local residents know that a usable ice bridge cannot be constructed in some years and that on these occasions they must use alternative routes. For residents of the Tangent area, Glacier suggested that the incremental one-way travel time to Peace River would be about 20 to 30 minutes if the Shaftesbury crossing were not available and that the driving time to the hospital at McLennan was about the same as the driving time to the Peace River hospital via Shaftesbury. For these reasons, Glacier concluded that no mitigation for any project impacts on the Shaftesbury crossing would be required.

### 5.4.2 Views of the Interveners

Ms. Liefbroer-Chenard stated that she represented about 300 people who lived in the vicinity of Tangent and Eaglesham who relied on the ice bridge and ferry crossing at Shaftesbury to cross the Peace River. She explained that these people were well aware that this access was unavailable for parts of the year during freeze-up and breakup but were reliant on the ice bridge and ferry for the majority of the year to gain to access to businesses, schools, and family on the opposite side of the river. She argued that any change in their ability to use the ice bridge or the ferry would have a significant impact on the local community, as well as on the businesses in Grimshaw, Fairview, and Peace River. In her case, Ms. Liefbroer-Chenard stated that without the ice bridge, the normal 32 km one-way trip to Grimshaw would become a 150 km trip under winter driving conditions. She disagreed with Glacier's assessment that this inconvenience would be relatively insignificant.

Ms. Liefbroer-Chenard noted that data collected by Alberta Transportation suggested that from 34 000 to 36 000 vehicles used the ferry during the open-water period (April to December) in 1998 and 1999. She reported that there were no equivalent records for use of the ice bridge, but suggested that winter usage would be somewhat lower than observed during the tourist season. Ms. Liefbroer-Chenard stated that to her knowledge, there had been no major incidents of people or vehicles falling through the ice bridge and noted that Alberta Transportation was now responsible for determining when the ice bridge was safe to use. She also observed that the ice bridge was actually more convenient for local residents since, when operating, it was available 24 hours per day, while the ferry only operated for part of the day.

With respect to how changes in the ice regime might affect the ability to construct an ice bridge, Ms. Liefbroer-Chenard suggested that Glacier had understated the potential impact of the project. She observed that in its assessment, Glacier concluded that the ice sheet might not be suitable for an ice bridge in normal and warmer than normal winters, so that an ice bridge could only be constructed in 9 of 10 years. However, she also noted that the TRICEP model predictions were only accurate to within 25 km, 68 per cent of the time. She suggested that because of this uncertainty, the ability to construct an ice bridge might be impaired in as many as 5 in 10 years and observed that this would be a much greater impact than indicated by Glacier. She also noted

that Glacier's predictions for a normal winter (1992-1993) showed that instead of 93 days of ice cover at Shaftesbury, there would only be 54 days of ice cover post-Dunvegan, and she submitted that this would represent a significant disruption of access for local residents. Ms. Liefbroer-Chenard also challenged Glacier's assertion that operating the ferry earlier in the spring and later in the fall could mitigate any shortening of the operating season for the ice bridge. She provided written submissions from the ferry operators, Mr. Bill Cowan and Mr. Gert van Butselaar, indicating that operation of the ferry during freeze-up was significantly limited because ice buildup on the pontoons affected steering. In addition, Mr. Alan Blakely, whose family had operated the ferry for 25 years, stated that any buildup of shore or border ice would interfere with the functioning of the ferry docking system and that the ferry freezes to the shore when docked overnight. He submitted that the ferry could not operate in any medium or heavy ice flow conditions. Based on this evidence, Ms. Liefbroer-Chenard concluded that it would not be possible to extend the operating season for the ferry as a means of mitigating the reduced operating season for the ice bridge.

Overall, Ms. Liefbroer-Chenard submitted that the Dunvegan project would have a significant impact on the operation of the ice bridge at Shaftesbury and that this, in turn, would affect a large number of area residents, especially farmers, who would have to travel much longer times and distances to access the businesses and services that they currently use. She noted that by classifying this route as a secondary highway and sanctioning the construction of an engineered ice bridge, the Government of Alberta had recognized its importance, and she argued that it would not be in the public interest to approve a project that would make this route less available to regional residents. She added that Glacier had offered no effective plans to mitigate or provide compensation for these impacts. She suggested that were the project to be approved, the only effective means of mitigation would be the construction of a bridge at the Shaftesbury location.

The Town of Peace River testified to the importance of the Shaftesbury ferry and ice bridge to regional residents and to the businesses in the town. It stated that it could not support a proposal that would reduce the time that an ice bridge would be operable. It also took issue with Glacier's claim that increased travel time when the ice bridge was inoperable would be insignificant, noting that any increase in travel time to a hospital would be very significant. The Town of Peace River also noted that the increased travel time would be highly significant for those families that faced a 1.5-hour drive instead of a 30-minute trip across the river.

### 5.4.3 Views of the Panel

In considering the potential impacts of the project on operations of the Shaftesbury ice bridge and ferry, the Panel understands that there is agreement among parties that changes in the ice regime would result in delayed development of a stable ice cover at this location in most years and that in warmer years an adequate ice cover may not develop at all. The Panel notes that while these predictions are consistent with the TRICEP model, the RICE model predicts no substantial change in the ice regime at the Shaftesbury site. What remains at issue is the significance that predicted changes in ice cover might have upon the ability to construct and operate the ice bridge for the benefit of local residents.

The Panel believes it is reasonable to conclude that delays in the development of the ice cover at Shaftesbury may delay construction of the ice bridge, which would adversely affect local residents and others who use the bridge to gain access to regional service centres. The Panel

disagrees with Glacier as to the significance of these impacts to residents, and it believes that impacts associated with increased travel time, especially under emergency circumstances, are quite significant. And since the evidence suggests that Glacier's proposed mitigation, namely, extended use of the ferry, may be impractical during freeze-up, the Panel concludes that this aspect of the project represents a negative impact to regional residents that may have been understated by Glacier.

## 5.5 Impacts on Wildlife Movements Across the River

### 5.5.1 Views of the Applicant

Glacier reported that its modelling predicted that there would be no impact on the ice regime downstream of Sunny Valley. In submitted that since the Paddle Prairie Métis Settlement was located downstream of Sunny Valley and about 350 km downstream of the Dunvegan site, the project would have no effect on the ability of moose to cross the river near the Settlement and no effect on the residents of the Paddle Prairie Métis Settlement.

### 5.5.2 Views of the Interveners

Mr. Alden Armstrong of the Paddle Prairie Métis Settlement told the Panel that residents of the Settlement lived a semi-traditional lifestyle and relied on fishing and hunting to provide a considerable portion of their food requirements. He noted that moose was a key wildlife species for the residents and he reported that moose in the area tended to travel east across the river in the winter months to gain access to the red willow that grew on the river flats. He reported that in a normal winter, the river froze over in December and the moose crossed over to feed on the willow until early March. He added that moose in the Buffalo Head Hills, located southeast of Paddle Prairie Métis Settlement, also feed on the red willow along the river.

In his opinion, any change to the ice regime of the river in the vicinity of Paddle Prairie Métis Settlement, such as a delay in the formation of the ice front, could adversely affect the ability of moose to cross the river. He submitted that this would have a significant impact on the residents of the Settlement. He noted that this sometimes happened in warm winters now, so any additional delay in the formation of ice on this reach of the Peace River could prevent moose from accessing a key winter food supply. He added that changes in the ice regime could also affect the movements of deer and wolf across the river.

Friends of the Peace told the Panel that more information on wildlife movements across the Peace River under current conditions was required. It questioned whether the methodology used by Glacier to determine wildlife movements was adequate and whether adequate studies had been undertaken in the areas immediately upstream and downstream of the weir where a number of significant tributary streams join the Peace River. Friends of the Peace noted that Glacier had provided no information as to whether there were any significant wildlife crossings in the area and had therefore concluded that questions relating to project effects on wildlife crossings had not been answered. Friends of the Peace suggested that more time was required to assess wildlife crossing of the river under current conditions and to predict what would happen with the project in place. It submitted that the existing information was inadequate for a clear determination of project impacts on wildlife.

### 5.5.3 Views of the Panel

The Panel observes that neither the TRICEP nor the RICE model predicts any effect on ice conditions downstream from Sunny Valley. Given this assessment and recognizing that Sunny Valley is located well upstream of the Paddle Prairie Métis Settlement, the Panel is comfortable that there would be little or no risk of the project affecting wildlife crossings in the vicinity of the Paddle Prairie Métis Settlement and other locations farther downstream from the project.

The Panel does believe, however, that the substantial changes in the ice regime predicted by the TRICEP model, specifically the open water downstream of the weir and the extension of the upstream ice cover, do have the potential to alter more localized wildlife movement patterns. The Panel agrees with the Friends of the Peace that additional data would be required to understand current large mammal movement patterns before the impacts of the project could be predicted.

## 6 EFFECTS ON THE PEACE RIVER FISHERY

A second major environmental concern identified by parties at the hearing related to potential impacts on the fish resources of the Peace River. Particular concerns related to how the project would affect the upstream and downstream movements of fish and how this might affect the long-term viability of fish populations in the river. Other concerns related to potential changes in habitat.

### 6.1 Fish Populations of the Peace River

### 6.1.1 Views of the Applicant

Glacier stated that it believed that it had a very good understanding of the fish species present, their relative abundance, size and morphology, migration patterns, and key habitat areas in the study area. It further stated that it used this information to design and assess the effectiveness of its fish passage structures.

Glacier reported that its studies had identified 19 species of fish in a 46 km reach of the Peace River, extending from 36 km upstream of the proposed weir to 10 km downstream. The 7 sport fish species identified by Glacier included, in decreasing order of abundance, mountain whitefish, walleye, burbot, goldeye, northern pike, bull trout, and kokanee. Of the 12 non-sport fish species, Glacier found that longnose sucker were most common, with smaller numbers of flathead chub, white sucker, northern squawfish, lake chub, longnose dace, redside shiner, spoonhead sculpin, slimy sculpin, spottail shiner, trout-perch, and fathead minnow. Based on the mix of fish species, Glacier characterized this reach of the Peace River as being a transition zone between cold water and cool water habitats.

Based on its studies, Glacier concluded that with few exceptions, the species composition and abundance within the fish community were consistent throughout the studied reach of the Peace River. It determined that some species, such as goldeye, used habitat in the region on a seasonal basis, whereas some other species, such as northern pike, longnose sucker, and white sucker, were resident.

With regard to the numbers of fish making use of the reach in question, Glacier noted that the problems associated with sampling fish populations in such a large river made it very difficult to produce reliable estimates of the absolute abundance of fish. Consequently, it explained that its fisheries assessment relied on an index of abundance, which reflected the number of fish collected per unit of sampling effort.

Glacier noted that a key consideration in its fish studies was to determine fish movements in the vicinity of the weir. In its June 2000 assessment it reported tagging 1461 fish and recapturing 40 of these. To supplement the results of its tagging program, Glacier stated that it also examined the results of previous studies addressing the key species found in this reach of the Peace River. Glacier noted that goldeye, walleye, mountain whitefish, and bull trout could all be characterized as being highly migratory, but it was unable to confirm whether this was the case for these species in the region of its proposed weir. For example, the results of its tagging program suggested that although there was some downstream migration of goldeye after the spring period, some remained in the study region to spawn. In addition, the tagging results for walleye also showed minimal movements. The limited data collected for both mountain whitefish and bull trout also showed little movement for these fish species.

Overall, Glacier stated that it was confident that based on the amount of fisheries information available, its predictions of migration patterns for the 9 key migratory species encompassed seasonal movement patterns and tendencies and were adequate for designing and assessing the effectiveness of its fish passage structures.

### 6.1.2 Views of the Interveners

SRD stated that in assessing the potential impacts of the project, it needed baseline information on the seasonal abundance of fish species, their movement patterns, morphology, and critical habitats, the current uses of the fishery, and the associated demands on fish populations. For this particular project, it noted that information related to species morphology and migration was required for it to be able to assess the effectiveness of the proposed fishways. With respect to the project, SRD noted that it had some information on species composition, relative abundance, life histories, and movement for some species for the Alberta portion of the Peace River and that it had reviewed the baseline data collected by Glacier in preparing its assessment of project impacts.

SRD noted that when compared to other rivers with fish passage structures, the Peace River was a very large river and, to date, the fisheries inventory work was still deficient in some areas. However, it noted that Glacier had committed to undertaking additional fish surveys and a detailed fish monitoring program and that the resulting information would be used to develop its project mitigation strategies. SRD stated that it was awaiting the details of the proposed fish monitoring program before determining whether the resulting information would be sufficient to be able to gauge and manage the project's impacts on fish.

### 6.1.3 Views of the Panel

The Panel appreciates the difficulty and considerable cost of undertaking a comprehensive assessment of fish populations, habitat availability, and movement patterns on a river as large as the Peace. The Panel also recognizes that the lack of previously collected comprehensive

information on fish populations makes it impossible for Glacier to be able to quantify the potential impacts of the project on fish populations without the expenditure of a significant amount of time and resources. Accordingly, the Panel understands why Glacier has focused its efforts on trying to minimize potential adverse effects on fish populations by designing effective fish passage structures.

However, since the proposed project represents a potentially significant barrier to both upstream and downstream fish movement, in the Panel's view, the very low recapture rates (2.7 per cent) reported in Glacier's tagging program provide little comfort that Glacier has a sufficient understanding of the fish populations in this region of the Peace River. Although Glacier has produced predictions of fish movements based on the combined results of a literature review, discussions with knowledgeable individuals, and expert opinion, the Panel is concerned that any unique characteristics of fish species in this reach of the Peace River have not been adequately captured. One obvious example is the lack of information on year-to-year changes in both movement patterns and abundance. The Panel is concerned that without better baseline information on both fish population size and movements, it would be problematic for Glacier to predict the ultimate effectiveness of its fish passage structures and the associated impacts to the various fish populations on either a local or regional basis.

## 6.2 Impacts on Upstream Fish Passage

### 6.2.1 Views of the Applicant

Glacier stated that upstream migration for most fish species found in the Peace River typically occurred from May to June, although mountain whitefish may be moving upstream during August and September. To ensure that these fish migrations would not be affected by the weir, Glacier proposed constructing two upstream fish passage structures, one at either end of the weir, that would allow fish passage during the open-water season.

Glacier explained that its current design of the upstream fish passage structures had been developed and assessed in consultation with DFO and SRD. While it had employed conventional vertical slot fishways in its first design and then considered a 50 m wide rockfill ramp fishway in its next design, Glacier stated that on the basis of numeric and physical models, it had concluded that a weir and pool sequence in a 10 m wide fishway with a submerged orifice headwork structure would best meet the design criteria set by DFO. According to Glacier, a key criterion was to maximize upstream passage opportunities for adult populations of goldeye, bull trout, walleye, mountain whitefish, and flathead chub, based on the burst and sustained swimming speeds of these species. It noted that the 10 m wide fishways also provided it with operational advantages over the 50 m design because the spillway structure could be enlarged to better allow passage of large volumes of water during flood events.

The upstream fish passage structure was described by Glacier as being a series of riffles and pools with a gradient of 20:1 and an open-water season design flow of 1.8 $m^3/s$. To create these hydraulic characteristics, Glacier stated that the positioning of specially shaped 900 mm cubes set about 300 mm apart would create depths and flows sufficient for passage of fish 150 mm and larger. Its design would also feature pools 4 m long across the width of the structure. It noted that hydraulic conditions along the margin of the fishways, which would consist of class II rip-rap,

might also allow fish less than 150 mm in length to move upstream, but acknowledged that it lacked the data to substantiate that opinion.

To provide suitable fish attraction flows, Glacier proposed placing guidewalls with two submerged orifices at the downstream entrance of each fishway. Glacier stated that it would construct a submerged orifice at the upstream end of each structure to provide consistent flow down the ramp regardless of the flows and velocities in the Peace River.

Glacier explained that a key factor in developing the design for the upstream fishways was the width and the location of the current fish migration corridors along each bank of the river under various flow conditions. To assess these corridors, Glacier employed a two-dimensional computer model to predict flow velocities for a 700 m reach of the river above the weir and a 2000 m reach downstream. Assuming that migration corridors for the fish species in the Peace River would be limited to areas where velocities were less than 1.0 m/s, it determined that the migration corridor along the south bank of the river was between 15 and 31 m in width, depending on the amount of flow in the river. For the north bank, Glacier estimated that the current migration corridor ranged from 22 to 97 m in width.

Glacier explained that it had developed a 1:10 scale physical hydraulic model to test various configurations for the fishway at the south end of the weir, including different bed types and different channel cross-section geometries. Glacier acknowledged that some further modifications of the proposed structure were required to optimize and refine the design for the south end of the weir and to determine the best configuration for the upstream fishway at the north end of the weir, which had a wider natural migration corridor. It stated that it had also not yet determined the quantities of attraction flows needed to optimize upstream fish passage. However, despite the need for this additional work, Glacier submitted that, in its view, the current design would successfully allow fish passage and that no adverse effects on fish populations would result. Glacier also submitted that notwithstanding this additional design work, its proposed design for the upstream fishway was satisfactory to both DFO and SRD. Furthermore, it committed to continuing to work with DFO to complete the additional design work, and it submitted a copy of its proposed work plan as evidence of this commitment.

With respect to operation of the fishways, Glacier stated that they would be operated in the open-water season but would be closed in the winter due to concerns about the generation of frazil ice during periods of cold air temperatures. It acknowledged that winter closure of the fishways might affect upstream movements of adult burbot, but it noted that burbot was considered a resident species and it did not believe that winter restrictions on movement would adversely affect the population. It also noted that closure of the fishways from December through March might also affect walleye migration, but noted that this migration typically occurred in late March or April and that the fishways could be operated in March if air temperatures were suitable.

Glacier also committed to develop a monitoring program to ensure that fish passage and survival rates were adequately assessed subsequent to construction. It noted that the upstream fish passage structures had been designed so that they could be modified after construction to accommodate a variety of fish passage strategies. Glacier submitted that with its "adaptive management" approach, it would be able to optimize fish passage operation after the facility had been built and, in this way, address any unforeseen issues.

With respect to criticisms of its earlier designs, Glacier noted that although its earlier design of the fish passage structures were based on the design of the Churchill River fishway, its current proposed design would be quite different. It noted that the Churchill fishway had no dedicated attraction flows and that water flows and velocities at that fishway were dependent on available river flows. In comparison, Glacier reported that it could manage its proposed structure in a manner that would ensure both adequate attraction flows and stable water flows through the fishways under a range of natural flow conditions.

In response to questions about whether the Panel had sufficient information for it to be able to assess project impacts on fish passage, Glacier submitted that the design of this project had already greatly exceeded what was done for other similar projects. Glacier suggested that more detailed design work would be very costly and could not be justified economically until after the project had been approved. It further submitted that it believed that it had provided sufficient information for the Panel to make its decision.

### 6.2.2 Views of the Interveners

Friends of the Peace commented that even though the design of the upstream fish passage structure had gone through several iterations, Glacier indicated that it still had to complete additional studies before the final design could be completed. In the opinion of Friends of the Peace, the regulators still do not have sufficient information to be able to make a decision about project impacts on fish resources.

Friends of the Peace identified several areas where it believed there were potential problems with Glacier's analysis. It suggested that the assumption that most fish travel up the channel margins was untested and needed to be verified. It questioned the potential impact on fish populations if fish smaller than 150 mm were unable to move through the fishway. On the assumption that fish demonstrated behavioural avoidance to trash racks, as claimed by Glacier (see Section 6.3), Friends of the Peace wondered whether similar avoidance behaviour might occur at the entrance and exit to the fishways and what effects this might have on fish passage. It suggested that more information on the width and gradient of an effective design was required before Glacier should be allowed to construct a fishway that could not easily be altered if subsequent monitoring determined that these characteristics needed to be changed. Friends of the Peace also stated that it was not convinced that the attraction flows would be adequate.

Friends of the Peace noted that a rock-filled fish ramp was used at the Churchill River weir in Manitoba and suggested that the effectiveness of that structure was substantially less than what was predicted. It stated that it had posed questions about the Churchill River weir to Glacier but had not yet received a response to these questions. Based on what information it did have, Friends of the Peace was of the opinion that the Dunvegan project would have a significant negative impact on the fish populations of the Peace River.

DFO stated that studies and modelling performed by Glacier since October 2001 had addressed many of the information deficiencies that remained after the EIA had been completed. It characterized Glacier's fish migration features as being feasible and innovative, but it noted that additional work was needed to quantify and finalize the design of the upstream fishway, especially in terms of the layout and dedicated fish guidance flows for the proposed rockfill ramp. However, DFO stated that it believed that an acceptable upstream fishway design could be

developed with continuation of joint work efforts and completion of additional modelling along the lines of Glacier's proposed work plan. DFO also noted that although some of the fish species in the Peace River may not have been recorded as using fishways, it was confident that the risk of a species not using the fishway was low.

DFO suggested that additional work was also required to evaluate the fish guidance conditions and the proposed headworks slot-orifice fishway where fish would exit into the headpond. DFO indicated that it was also concerned about how fish would be guided to the fishway entrances and suggested that some additional modelling work was required to quantify and fine-tune the design of the south bank fishway and to develop the appropriate design and modelling for the north bank fishway where flow conditions were expected to be quite different. It added that it was also concerned about cumulative delays in fish finding the structures or fish accumulation in the structure, and it specified that a monitoring program and adaptive management strategy would be required if the project were to proceed.

SRD stated that its objectives for successful upstream fish passage were that the downstream approaches to the dam would funnel fish to the entrance of the fishways and that the depth and velocity of water in the fishways would be adequate for all sizes and species of fish to freely move upstream around the structure. In its opinion, Glacier's designs were not yet complete but SRD believed that the fishway impacts could be successfully mitigated through additional modelling and design modification. In terms of work to be completed for the fishway at the south end of the weir, SRD submitted that Glacier needed to determine suitable attraction flows, decrease the velocity of flows in the headworks, and conduct a final assessment of the fishway against performance requirements. It also noted that Glacier still had to complete its design and assessment for the fishway at the north end of the weir.

SRD stated that there was a strong likelihood that the remaining issues could be resolved through additional modelling and design work by Glacier and by having a structure that could be adapted and modified after construction to accommodate the needs of the various fish species. SRD also noted that Glacier had proposed developing and implementing a postconstruction monitoring program.

### 6.2.3 Views of the Panel

With regard to upstream passage of fish, the Panel notes that DFO has been heavily involved in the project with the applicant. As a result, the Panel would be prepared to accept the assurances of both DFO and SRD that the design would ultimately be able to allow fish passage, although what degree of success would ultimately be achieved was significantly less clear.

In coming to this conclusion, the Panel notes that Glacier, in close collaboration with DFO, had significantly improved upon its original designs for the proposed upstream fish passage structures. The Panel believes that Glacier's use of physical scale models to generate and test proposed design features is a substantive and significant step in ensuring the eventual success of the fishways. The Panel can also understand the company's reluctance to invest even more funds into detailed design without some assurance that it will receive approval of its project.

The Panel notes that while both SRD and DFO advise that they believe that the remaining issues can ultimately be addressed through an "adaptive management" strategy, it is very clear that the

proposed design already represents a significant commitment of engineering and capital investment for the applicant. It is not clear, however, to what extent even further design work can be supported should extensive design modifications or changes to flow regimes prove to be required once the fishway has been constructed.

In addition, the Panel shares the concerns raised by the Friends of the Peace regarding behavioural avoidance of the fishway entrance and the ability of fish smaller than 150 mm to move through the structure. The Panel also has concerns about potential impacts on fish populations, such as burbot, that move upstream during the winter months, since the fishways would not be operating during December through March. This latter issue is particularly problematic because available evidence on fish movement patterns in the vicinity of the weir on either a seasonal or annual basis is very limited.

The Panel also notes that the proposed fishway is significantly narrower than the river margin where upstream fish migration is currently predicted to occur and, furthermore, that Glacier itself accepts that hydraulic conditions differ significantly between the two banks. Therefore, without Glacier having completed additional design work on the fishway at the north bank and an assessment of the effectiveness of this design to attract and pass fish, the Panel is unable to gauge the potential impact of the project on upstream fish movements along the north shore of the Peace River.

## 6.3 Impacts on Downstream Fish Passage

### 6.3.1 Views of the Applicant

Glacier submitted that its current project design had several features that would allow downstream fish passage and minimize fish mortality through the turbines. It explained that its design (see Figure 4) included a series of trash racks and sluiceways that would divert adult fish around the turbines, that the style of turbine used in the powerhouse was selected to maximize the survival of smaller fish that may pass through the turbines, and that the ogee-style spillway would result in very low mortality for any fish that did pass over the spillway. Glacier observed that during the key months for downstream fish passage (August through October), river flows would be small enough that there would be little if any flow over the spillway, so that all fish would be passing through the sluiceways, fishways, or turbines. It also expected that for the mix of fish species in the Dunvegan area, most fish would gravitate towards the channel margins as downstream passage routes.

In order to exclude adult fish from the turbines, Glacier proposed using low-angle (~15 degrees to the horizontal) trash racks covering groups of five turbine intakes. In deciding the appropriate spacing between the bars in the trash racks, Glacier indicated that it had to balance turbine efficiency, exclusion of debris (including ice), and fish impingement. Based on the morphology of the migratory fish in the Peace River, it decided that a spacing of 45 mm and a water velocity of 0.35 m/s through the racks would be sufficient to exclude adult fish, while ensuring operational requirements were maintained.

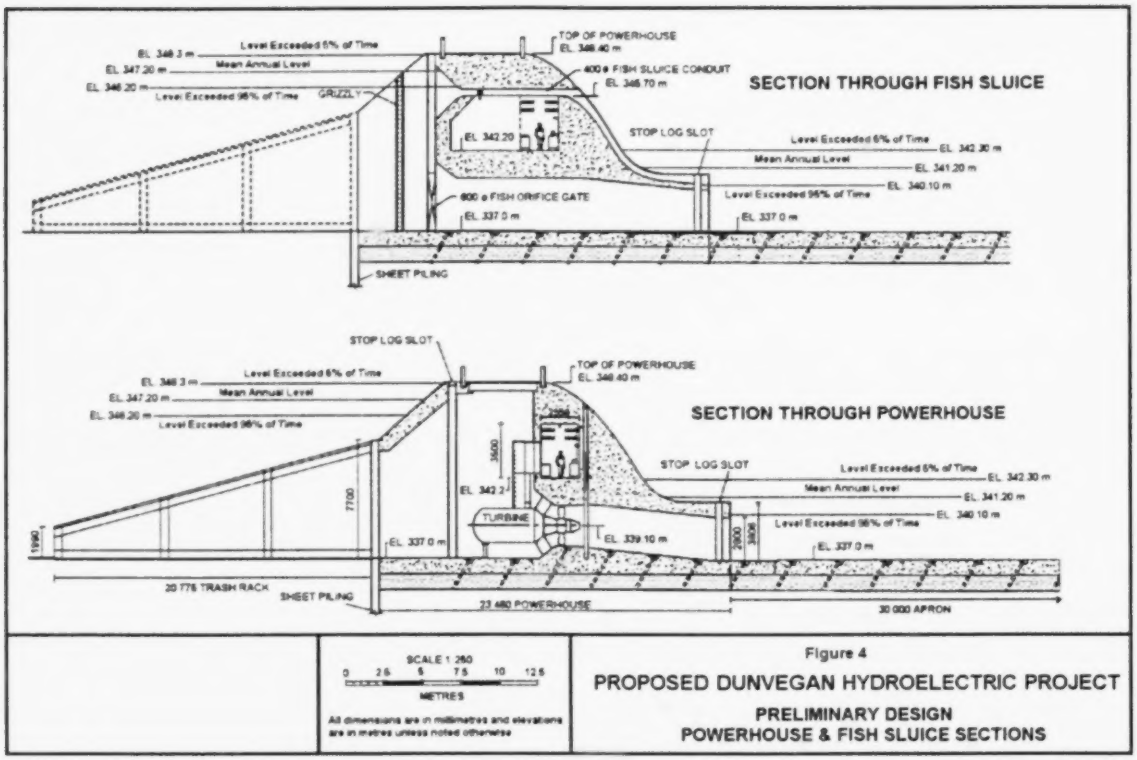



Figure 4

**PROPOSED DUNVEGAN HYDROELECTRIC PROJECT**

**PRELIMINARY DESIGN**
**POWERHOUSE & FISH SLUICE SECTIONS**

To assist in the determination of optimal bar spacing in the trash racks, Glacier explained that it conducted a study in October 2001 to determine the morphology of key migratory fish species. Glacier noted that this study was conducted at a location on the Peace River near the B.C.-Alberta border. Body length, width, and depth measurements were taken for five fish species with sample sizes ranging from 9 to 92 fish. Based on its analysis of the fish measurements, Glacier determined that most of the large fish species, with the exception of mountain whitefish, would be sexually mature at fork lengths of 300 mm or greater and it accepted this as the minimum target length of fish to be excluded by the trash racks. Based on the results of the analysis, a trash rack spacing of 23 mm would be required to physically exclude all of the adult fish included in the sample.

However, Glacier noted that trash racks could be designed in a manner that would evoke a behavioural response from fish to further reduce the possibility of fish entrainment. It explained that fish can sense the changes in water velocity and turbulence resulting from a trash rack and suggested that fish would then search for a preferred route around such an obstacle, such as the proposed sluiceways. In support of this view, Glacier submitted the results of literature review and technical analyses by Alden Research showing fish entrainment rates for various types of trash rack designs and spacing and various fish species. It noted that four factors should be considered in designing trash racks that would minimize entrainment of adult fish. These were to minimize clear spacing (bar spacing) to the extent possible, minimize the angle of the bar racks to the approach flow, minimize the distance that fish have to traverse along the racks before reaching a bypass, and maintain approach velocities of about 1 m per second or lower.

Alden Research found that even at sites with bar rack spacing ranging from 60 to 250 mm, fish larger than 380 mm constituted less than 1 per cent of all fish entrained. When it evaluated a trash rack design for Dunvegan based on a bar spacing of 60 mm, Alden Research concluded that the overall downstream passage survival rate for fish over 300 mm in length would be 92.5 per cent, based on an assumed guidance rate of 50 per cent and a conservative turbine survival rate of 85 per cent. However, it acknowledged that there remained some uncertainty about whether efforts of the fish species in the Peace River to search out the bypass structures and migrate to a specific area within a specified time period would be comparable to that of the fish species studied in the literature on trash rack design and performance.

In selecting a design based on 45 mm bar spacing, Glacier proposed that this design represented a balance between excluding fish and effective debris management, which is an issue on the Peace River. It stated that narrower spacing of the trash racks would cause engineering problems in terms of removal of debris and blockage of the racks and could also affect project economics by reducing energy production. In addition, to deal with potential problems with ice formation, it proposed to remove the upper sections of the trash racks during the winter months (November through March) but stated that this would not adversely affect most fish populations, since most species of fish do not migrate during this period. Glacier acknowledged that during the winter months, there would be some downstream movement of burbot (adult, eggs, and larvae) and juvenile and adult bull trout and walleye, but noted that the trash racks would remain in place below the ice cover.

With respect to whether the proposed trash racks might cause some impingement of fish, Glacier reported that based on its modelling studies, the predicted water velocities along the surface of the rack would only be in the range of 0.3 to 0.4 m/s. Since this is well below the sustained swimming speeds for most fish species, Glacier concluded that fish impingement would not occur.

With respect to the effectiveness of the proposed bypass sluices, Glacier noted that its proposed weir design featured seven bypass conduits located between every fifth turbine unit and containing upper- and lower-level passage sluices. It submitted that the sluices were positioned to optimize guidance of fish toward the sluiceways and that the sluiceways could also be used to manage flows during flood events. Glacier reported that it had conducted some evaluation of the design using a 1:25 scale section model to assess downstream attraction to the sluices and to determine whether sluice velocities would be sufficient to prevent upstream fish movements. It noted that results of the modelling showed that the lower conduit provided a more effective guidance flow than the upper conduit, although this was affected by how the turbines were being operated. Glacier acknowledged that additional design and testing of the bypass conduits was required before a final design would be determined, but it was confident that this design concept would be adequate to allow passage of adult and other fish that would be diverted by the trash racks. Based on the use of bypass conduits at a similar low-head hydroelectric facility in Vermont, it predicted that fish survival rates would be 100 per cent.

In terms of turbine selection, Glacier stated that the bulb-type turbine units incorporated into its project design were recognized by the industry to be the best available technology in terms of fish survival. Based on a technical review of turbine technology conducted by Alden Research, Glacier was of the opinion that this style of turbine, when combined with the low project head, the absence of wicket gates, and the operation of the turbines at peak efficiency, would minimize

both acute and long-term mortality for those fish that did pass through the turbines. For fish small enough to pass through the proposed trash racks, Glacier predicted that the high turbine survival rate, when combined with avoidance behaviour, would result in an overall turbine-related survival rate of nearly 97 per cent.

Glacier further submitted that the incorporation of an ogee-style spillway and stilling basin in the project design would result in survival rates of 90 to 100 per cent for fish of any size that passed over the spillway. While it stated that the final design of the spillway had yet to be determined, it was confident that it would satisfy hydraulic conditions for safe fish passage, namely, adequate water depth at the base of the spillway and a maximum water velocity of 15 m/s.

Overall, Glacier concluded that its proposed combination of trash racks, bypass sluiceways, turbines, and spillway design would meet the design requirements of both DFO and SRD. In predicting the overall mortality rate for the facility, it assumed that all fish greater than 300 mm would be diverted through the sluiceways by the trash racks and that turbine survival rates for smaller fish would be 95 per cent for fish under 100 mm, 90 per cent for fish 100 to 199 mm, and 88 per cent for fish 200 to 299 mm. Its evidence showed that estimated survival rates would vary by fish species, ranging from 90.5 per cent for mountain whitefish, to about 95 per cent for minnow, shiner, and sculpin species, and to 100 per cent for goldeye.

However, Glacier also acknowledged that it did not have enough information to provide exact success rates for the bypass structures. It submitted that as a result, it planned to develop a conceptual monitoring plan prior to construction and adapt its operations of the downstream fish passage structures, including the closure of selected turbines during low flow periods, to ensure that impacts on downstream fish movement were minimized. At the hearing, it also acknowledged that it was still prepared to make design changes, such as decreasing the trash rack spacing to 40 mm, if required as a result of further consultations with SRD and DFO.

### 6.3.2 Views of the Interveners

Friends of the Peace noted that the effectiveness of the downstream fishways was dependent on the assumption that fish would use the channel bottoms and margins for their downstream movements. It stated that, in its opinion, this assumption should be verified by scientific studies before the project was given further consideration. Friends of the Peace also questioned whether the assumptions about appropriate attraction flows, the behavioural avoidance to trash racks, and the effectiveness of fish passage conduits through the structure could be supported by scientific research. Without more convincing information, Friends of the Peace submitted, there was still reason to doubt that fish passage could be accommodated by Glacier's proposed design.

With respect to downstream fish passage, DFO submitted that while the proposed trash racks and bypass sluices held promise, additional work needed to be done to finalize the design and operation plans for the facilities to optimize survival rates. In its opinion, this would entail quantifying flow regimes and developing a monitoring program to verify the effectiveness of the proposed downstream fish passage system and identify any additional modifications.

DFO proposed that Glacier re-evaluate the proposed 45 mm bar spacing on the trash racks in light of fish morphology data that, in its opinion, suggested that a smaller spacing might be required to exclude all adult fish. It noted that Glacier was unable to provide morphology data

for goldeye, and since these fish are the most laterally compressed of all fish species in the Peace River, it recommended that Glacier use the smallest bar spacing possible to minimize fish losses through the turbines.

DFO also cautioned against assuming that the fish guidance statistics observed at other facilities would apply to the Dunvegan design. DFO observed that the trash racks being proposed by Glacier would be submerged and inclined to the horizontal, which would be hydraulically different from most other systems. Furthermore, DFO noted that for many species of fish found in the Peace River, very little was known about their behavioural responses to trash racks and fish screens. It stated that these behavioural responses could, however, be determined using laboratory studies of fish, and although no such studies were planned, DFO suggested that they might be required unless Glacier adopted a smaller bar spacing.

DFO also suggested that the survival rates assumed by Glacier in assessing turbine mortality must be interpreted with caution. It advised that for the types of fish species in the Peace River, there were limited data on and experience with turbine losses. With respect to the ogee spillway, DFO noted that the success in passing fish over the structure would rely on constructing the facility according to the proposed design and operating the spillway in a manner that ensured that flow acceleration rates were kept within the desired range.

With respect to monitoring project impacts, DFO stated that it agreed with Glacier's proposed framework and noted that a detailed monitoring plan developed and approved by DFO and SRD would be a condition of any subsequent Fisheries Act authorization for the project. It agreed that there should be some flexibility to fine tune the design and operation of the facility to improve the efficiency of fish passage but expressed concern that significant changes to the structure or its operation that affected power generation may not be practical or feasible.

SRD stated that its objectives for downstream fish passage were to minimize the number of fish going through the turbines by permitting only small fish to pass through the turbines and successfully directing larger fish downstream through the weir or over the spillway. It noted that a key aspect of Glacier's design was to install fish screens (trash racks) to preclude adult fish (over 300 mm) from entering the turbines, but it believed that the bar spacing proposed by Glacier needed further consideration, especially for goldeye. In SRD's opinion, Glacier still needed to undertake additional studies on the physical and velocity guidance to fish for downstream conduits, the amount of water needed for downstream passage for attraction flow, and ways to adapt its hydroelectric generation operations to ensure downstream fish passage. It also noted that Glacier still had not submitted the final design of the ogee spillway. However, despite the requirements for additional information, SRD indicated that it believed that Glacier would likely be able to address its remaining concerns.

### 6.3.3 Views of the Panel

The Panel notes that while there appeared to be a common view among the applicant, SRD, and DFO with respect to the goals of the downstream fishway structures at the hearing, there also appeared to be significant differences in their views as to the eventual efficacy of the proposed designs, particularly for the trash racks.

The Panel has some particular concerns in this regard. The first is the adequacy of the information on fish morphology used to select the design criteria for the trash racks. The Panel notes that Glacier provided this information in response to a request from DFO and AENV that 50 fish of each of four species (goldeye, mountain whitefish, northern pike, and burbot) be sampled. The Panel notes that the fish morphology study was able to provide more than 50 samples for only one of these species (mountain whitefish), only 9 samples of northern pike, and no samples of the other two species. Given the lack of information, especially for goldeye, which were determined to be highly migratory, the Panel is concerned that the 300 mm fork length criterion used by Glacier in designing and assessing the effectiveness of the trash rack design may not be appropriate.

Furthermore, while the Panel heard from Glacier that the 45 mm spacing of trash racks already represented a significant compromise between operational constraints and successful exclusion of adult fish from the turbines, it also heard DFO indicate that smaller trash rack spacing may be required because it was unclear whether fish species in the Peace River would exhibit the trash rack avoidance response assumed by Glacier. The balance of the evidence suggests that there is still considerable uncertainty about the effectiveness of Glacier's proposed design, and without some degree of certainty on this element of the project, the Panel is not able to understand the extent to which the Dunvegan project might adversely affect downstream fish movements. Nor is it clear to the Panel the extent to which the facility could be adaptively managed to address fisheries concerns and still remain cost effective to operate. The Panel notes that DFO expressed similar concerns, although SRD appeared to be more comfortable that this issue could eventually be satisfactorily addressed.

Without a better assessment of the extent to which the effectiveness of the downstream fishways will affect the long-term viability of fish populations in the Peace River and the impact of eventual trash rack design on project economics, the Panel's ability to fully understand this aspect of the public interest is limited.

### 6.4 Impacts on Fish Habitat

#### 6.4.1 Views of the Applicant

Based on its field investigations, Glacier characterized the reach of the Peace River that would be affected by the project as having limited amounts of high-quality fish habitat. It noted that the channel was relatively shallow, water velocities were quite high, and there was limited vegetation cover, so there were few areas where fish could seek shelter from the current. Although some higher-quality habitat was available along the riverbanks, Glacier determined that the extent of the habitat was quite limited and was also subject to change because of flow fluctuations associated with upstream power production. It identified some shoal and riffle/rapid habitat, but concluded the amount of this type of habitat was small relative to the length of the river it surveyed. As for the small tributary systems, Glacier submitted that because of bank instability and low flows, these were generally incapable of supporting resident sport fish species, although they did provide some seasonal habitat for cyprinid and sucker species.

Glacier stated that it had identified two critical habitats in the area. It reported finding a walleye spawning area on a shoal about 17 km upstream of the proposed weir and a northern pike

spawning area on an inactive side channel about 9 km upstream. In both cases, however, Glacier concluded that these areas were already adversely affected by flow regulation.

Glacier stated that construction and operation of the project would result in some alteration of fish habitat. Although there would be some direct habitat losses during construction, Glacier stated that the formation of the headpond would eventually provide additional wintering habitat, which it believed was available in only relatively limited amounts at the present time. It suggested that the project would increase the area of side channel habitat by about 100 to 150 hectares, since these areas would no longer be dewatered by flow regulation.

Glacier also acknowledged that with increased water depth, reduced velocity, and increased sedimentation, some existing upstream spawning habitat would be adversely affected, including the walleye spawning area. It suggested that some of this loss might be offset if similar habitat evolved as cobbles and gravels were deposited in the river at the extreme upstream end of the headpond. Further, Glacier committed to explore opportunities to create high-quality pike spawning and rearing habitats in the headpond and high-quality walleye spawning habitat in the tailrace zone below the weir. On balance, Glacier concluded that there would be no net loss of habitat as a result of the project and submitted that this would be satisfactory to DFO.

### 6.4.2 Views of the Interveners

DFO stated that, in its view, it would be possible to either mitigate or compensate for the impacts of the Dunvegan project on fish habitat. It acknowledged that there would be some loss of habitat caused by the structure itself and up to 8 km downstream as a result of changes in flow patterns. DFO indicated it would be seeking compensation for habitat losses in the project footprint, but it had not yet established the extent to which there would be a net gain or loss of habitat.

### 6.4.3 Views of the Panel

Since DFO is directly responsible for ensuring that there would be no net loss of fish habitat, the Panel would be prepared to accept its assessment that the project's impacts on fish habitat would be capable of being mitigated or compensated. However, the Panel notes that Glacier's Application contains no information related to the extent or cost of either mitigation or compensation, and it appears that these requirements would not be known until sometime after the Panel's decision. While this may be satisfactory to DFO, the Panel is unable to conclude at this time what the net impacts of the project on fish habitat would be.

## 6.5 Impacts on Fish Populations

### 6.5.1 Views of the Applicant

Glacier stated that the Dunvegan project would not have a significant negative impact on fish populations in the Peace River. Because of its work to design structures that would allow downstream fish movements through or over the structure and upstream fish passage around the weir, it submitted that impacts would be minimized.

Glacier submitted that while it would have been preferable to evaluate the impact of the project on all life stages of fish, it had focused on whether the project would affect adults, which are considered by most fisheries managers to be the most critical component of fish populations.

Although it admitted that it would be very hard to quantify what fraction of the adult fish population might be adversely affected by the project, Glacier proposed that a reasonable worst-case adult survival rate for downstream fish passage would be in the range of 93 to 95 per cent and the expected survival rate for adults would exceed 98 per cent. Glacier stated that it further concluded that the fish community structure would not fundamentally change as a result of the project. Glacier argued that its project would result in less than the 10 per cent mortality that would be allowed under SRD's fisheries mortality guidelines. Furthermore, it submitted that the Dunvegan project, as proposed, would satisfy DFO's requirements that there be no net loss of habitat.

Glacier acknowledged that additional work would be required to finalize the design of the fish passage structures and to collect some additional fisheries data before DFO would be able to issue the required authorizations. However, it noted that both DFO and SRD had committed to continue to work with Glacier to complete the additional design work, its work plan had been approved by DFO, and both agencies had stated that they expected that an acceptable design was achievable. Glacier further submitted that there was enough flexibility in the design and operation of its proposed facility that it would be able to adaptively manage the facility to ensure that fish passage was optimized and that any unforeseen issues could be addressed. Although it had not yet developed its monitoring plan, Glacier believed that the Panel now had sufficient information to be able to make a public interest determination.

In response to concerns raised by the Friends of the Peace, Glacier acknowledged that turbine operations and the passage of water through spillways could result in increased total gas pressure (TGP) in the water column below hydroelectric facilities and that excessive levels of TGP could be harmful to fish. However, it noted that being a run-of-river design, the Dunvegan project would not increase TGP, so there would be no resulting impacts on fish.

In response to concerns from Friends of the Peace about the potential adverse impact that slumping of riverbanks would have on the health of the river ecosystem, Glacier stated that it concluded that there would be no large-scale slumping in the reservoir, based on its geotechnical studies. It noted that although the banks of the Peace River are unstable over most of its length, the section containing the headpond has favourable slope conditions, with only a thin veneer of materials that would be susceptible to surficial sliding. It further noted that small-scale slumping events are presently an integral part of the river ecosystem and in fact benefited fish by increasing habitat complexity along the riverbanks. With the project, it predicted that while small-scale slumping in the headpond areas would increase in the short term, any resulting increase in sediment levels would be very small and would not adversely affect resident fish populations.

With respect to its fish-monitoring program, Glacier explained that various methods could be used to determine whether fish movements were being delayed, what passage routes were being used, and the rates of fish mortality. It listed these methods as including fish inventory techniques, radio telemetry, and controlled studies of fish passage effectiveness. Glacier noted that a final plan had not yet been developed and development of the plan could involve consultation with DFO and SRD.

### 6.5.2 Views of the Interveners

Friends of the Peace stated that it regarded the evidence related to the design and operation of the fish passage structures as being a work in progress. It noted that substantial changes had been made from the design provided by Glacier in 2001 and observed that Glacier had committed to undertaking further design work in association with SRD and DFO. Friends of the Peace concluded that Glacier was asking the Panel to accept in good faith that work yet to be completed would result in a facility that would have no impact on the long-term viability of fish populations. Friends of the Peace stated that it did not believe that the Panel had the information on fisheries impacts it needed to make a public interest determination. Friends of the Peace suggested that the Panel delay its decision until such time as the final design of the fishways and bypass structures had been completed and evaluated.

Friends of the Peace also questioned how the efficiency or effectiveness of the fish passageways would be assessed. It submitted that measures to determine how many fish used the structures would not account for mortality-related delays in migrating to spawning areas. It noted that since Glacier's approach focused on survival rates of adult fish, the remaining fish appeared to have been considered expendable, and it questioned what effects this might have on the long-term sustainability of fish populations. It also observed that even if the survival rates for adult fish migrating past the structure predicted by Glacier were accepted, the combined annual mortality of fish passing upstream and downstream could exceed SRD's 10 per cent mortality guideline.

Friends of the Peace also raised questions about increases in TGP in the water column as a result of water flowing over the weir. It noted that TGP was of concern to regulators considering a similar weir in B.C. and suggested that the potential impacts of the Dunvegan project needed to be considered before it should be allowed to proceed.

DFO stated that with regard to project impacts on fish, there was a separate and ongoing assessment under the Canadian Environmental Assessment Act that required it to decide, by way of an environmental screening, whether the Dunvegan project would cause significant effects on the environment. It also noted that before it could proceed, Glacier would have to acquire authorizations under the Fisheries Act for the destruction of fish and the alteration of fish habitat. DFO stated that its objective for the project was to provide reliable upstream and downstream fish passage to maximum numbers of each fish species and to the widest range of fish sizes. DFO reported that the federal assessment of the project had not yet concluded, but noted that it intended to continue to work with Glacier to address some outstanding questions. It acknowledged that it had no idea of what estimated mortality rates for fish would be as a result of the project.

Although it believed that further work was needed to quantify and finalize the upstream and downstream fish passage structures and their operation, DFO stated that continued work with Glacier would result in the development of acceptable fish passage structures. DFO submitted that it was generally also satisfied that any direct losses in fish habitat resulting from the project could potentially be mitigated or compensated for in a manner consistent with its no-net-loss policy. It added that implementation of mitigation measures and development of a fisheries monitoring program, including possible requirements for additional baseline field studies, would be conditions of any future Fisheries Act authorization.

DFO advised the Panel that if monitoring showed that fish mortalities still exceeded the predictions, the authorization would also include some conditions, yet to be determined, related to enhancement and compensation. DFO also requested that the Panel, in making its public interest decision, address the impacts of the Dunvegan project in the context of possible other hydroelectric projects on the Peace River.

SRD stated that its assessment of the Glacier project was framed in the context of two management objectives. The first objective was to sustain the abundance, distribution, and diversity of fish populations at the carrying capacity of their habitats and to allocate fish beyond conservation needs to achieve the greatest overall benefits. The second objective in evaluating Glacier's proposal with respect to sustaining fish populations was to minimize mortality associated with the fish passage structures, because cumulative annual mortality exceeding 10 per cent could affect sustainability. SRD explained that the 10 per cent mortality guideline was based on the results of extensive lake monitoring programs and served as a useful guideline for making judgement calls on the acceptability of the mortality rates for the fish passage structures. Since conditions in the Peace River were less stable than in a lake environment, it agreed that fish populations in the river might be better adapted to deal with short-term adverse environmental effects.

SRD noted that it expected the predicted mortality rates for adult fish to be very low because the trash racks would divert them through the bypass conduits. SRD submitted that although it was unclear exactly how Glacier had determined the exact mortality rates for the proposed fish passage structures, it had been able to conclude that the predicted rates were valid estimates and it believed that they would be less than 10 per cent. SRD also noted that for this reach, fishing pressure was quite low. Overall, it was confident that with adaptive management, the combined effect of the project and other causes of fish mortality would not exceed the 10 per cent mortality guideline. It further stated that although some additional work on the design and operation of the fishways was still required, it was confident that Glacier would be able to resolve its outstanding concerns.

### 6.5.3 Views of the Panel

In considering the potential impacts of the proposed project on fisheries, the Panel notes that there remain a number of unresolved issues. First, the Panel does not believe that it has sufficient information to truly understand the current composition of the fish populations within the affected area of the Peace River, their vulnerability to new potential sources of mortality, or the effects of potential loss or impairment of access to upstream or downstream habitats. Even basic data with regard to current sources of mortality, such as the operation of the upstream dams by BC Hydro and the magnitude of current mortality rates (vis-à-vis SRD's 10 per cent mortality rule), were not presented at the hearing.

Further, while the Panel is comfortable that Glacier has made significant strides in redesigning both its upstream and downstream passage structures, the Panel notes that there remain a number of unresolved questions around both their ultimate configuration and their potential efficacy. In addition, while Glacier has suggested that if unexpected design issues do arise, they can be addressed through adaptive management techniques, the Panel saw little evidence that the project design could accommodate any further substantive changes if these were determined to be needed. The Panel notes that many of these issues still remain to be resolved among the

applicant, DFO, and SRD. However, based on the uncertainty in the evidence currently before it, the Panel is unable to ascertain the extent to which the project would cause fish mortality and how this would relate to the fisheries management objectives for the Peace River.

In its submission, DFO asked that the Panel include an assessment of the potential impacts of other developments on the Peace River when determining whether the project was in the public interest. However, without significantly more information, the Panel is also unable to meet this request.

# 7 OTHER PROJECT EFFECTS

## 7.1 Impacts on the Peace-Athabasca Delta

### 7.1.1 Views of the Applicant

Glacier advised the Panel that the Dunvegan project would not affect the downstream flow regime of the Peace River because it would be a run-of-river operation. Consequently, it concluded that it would have no impact on hydrologic conditions in the Peace-Athabasca Delta (PAD).

Glacier acknowledged that it was aware of efforts by some parties to "naturalize" the flow regime of the Peace so that hydrologic conditions in the PAD might return to pre-Bennett Dam conditions, but indicated that it was unwilling to speculate on how the river regime might be changed to meet these demands. Glacier noted that the financial viability of the Dunvegan project had been calculated based on the current flow regime as regulated by BC Hydro in conjunction with the JTF and cautioned that any future modification of the flow regime could decrease its ability to generate power and revenue. In its assessment, a return to pre-Bennett flows would decrease its revenues by half. However, Glacier indicated that were the project to be approved, it would be willing to work with other river users to develop a new management regime for the Peace River.

With respect to occasional releases of water by BC Hydro to increase the potential for a major ice jam during spring floods to benefit the PAD, Glacier indicated that the project was designed to accommodate high flows and would be unaffected by such releases for a one- to three-week period and with a return rate of about one year in ten.

### 7.1.2 Views of the Interveners

Parks Canada explained that floods were important to the PAD, located in Wood Buffalo National Park, and that it was concerned that the operations of the proposed Dunvegan project might impinge on developing future management options that might help restore environmental conditions in the PAD. It reported that agencies had been working to improve environmental conditions in the PAD since the early 1970s, at which time it was believed that regulation of the Peace River associated with filling and operating the Williston Reservoir was responsible for extremely low water levels in the PAD. Parks Canada recalled that early experimentation with constructing weirs in channels in the PAD had a limited effect on maintaining water levels in the large lakes in the PAD. It explained that the weirs did not recharge the perched basins that had normally received water during overland floods prior to the Bennett Dam and had formerly provided large amounts of habitat for muskrat and waterfowl.

According to Parks Canada, the importance of spring ice jamming to create flood events that would fill the perched basins was recognized in the 1990s. Since that time, it and other agencies had studied the historical relationship between the effects of weather and river regulation on environmental conditions in the PAD and had concluded that wet and dry periods were normal and that the dry conditions during the past 30 years were not out of the ordinary. Parks Canada also reported that an ecosystem management plan had been developed in association with other agencies, but stated that it had not yet been signed because of ongoing aboriginal rights litigation involving the Athabasca Chipewyan First Nation versus BC Hydro, the Province of B.C., and the Federal Government and other litigation involving the Mikisew Cree First Nation versus the Government of Alberta and the Federal Government.

Parks Canada told the Panel that because of the importance of flooding to the PAD, in 1996 Alberta had requested that BC Hydro release extra water at a time when a major spring ice jam was expected so that the chances of flooding would be increased. It acknowledged that BC Hydro had complied with this request, and although it was not currently negotiating with BC Hydro to do this routinely, it anticipated that a similar request might be made in the future. Parks Canada suggested that based on current knowledge, such requests might be submitted once every 10 years and might entail increased flow releases lasting one to three weeks.

As managers of the PAD ecosystem, Parks Canada indicated that it was concerned about any project that might affect future management of the Peace River and potentially limit options for the PAD. In the opinion of Parks Canada, approval of the Dunvegan project might limit management options for the PAD because the financial viability of the project was dependent on maintaining the existing regulated flow regime. Were the project to be approved, Parks Canada agreed that it would be beneficial for Glacier to participate in working groups established to assist in the management of the Peace River.

Friends of the Peace submitted that approval of the Dunvegan project would impede discussions with BC Hydro regarding modifying its operating regime to better address water demands in the PAD because revenues from the project would be dependent on maintaining the existing flow regime. Friends of the Peace suggested that if the project were to be approved, Glacier should be required to accept whatever agreement was made between BC Hydro and the Government of Canada and that Glacier not be allowed to intervene in the process of developing this agreement or to seek compensation.

The Paddle Prairie Métis Settlement testified that the Northern River Basins Study stated that remediation of the PAD was limited by the absence of natural flows and advocated that water needed for hydropower production should not take precedence over water demands for environmental stability.

BC Hydro also questioned whether the information assembled to date was able to clearly relate observed changes in the hydrology and ecology of the PAD to flow regulation associated with its hydroelectric operations on the Peace River. It noted that there was some evidence that the changes may be part of natural ecosystem variability. Furthermore, BC Hydro suggested that the Dunvegan hearing was not the appropriate venue for addressing this question.

BC Hydro confirmed that in 1996 it had released water at the request of Parks Canada to enhance the potential for spring flooding in the PAD since conditions suggested a high probability that

there would be an ice jam. It explained that it released extra water at a time when it normally reduced flows because of decreasing power demand to test whether higher flows would affect flooding in the PAD. However, it noted that the test was inconclusive because by the time the released water reached the PAD, the ice jam had broken. BC Hydro indicated that it was prepared to consider making similar releases to benefit the PAD but doubted whether the development of the Dunvegan project would preclude it from making such releases in the future.

### 7.1.3 Views of the Panel

The Panel notes that Glacier expressed a willingness to accommodate efforts to restore periodic flood level flows to benefit the perched basins in the PAD provided that it would not have a significant adverse impact on its project. The Panel also observes that Glacier's concerns only related to the potentially significant impact that a return to natural pre-Bennett conditions would have on project revenues. None of the evidence at the hearing, however, suggested that future "naturalization" of flows would likely consist of anything more than relatively infrequent short-term releases of large amounts of water to enhance flooding of the PAD. The Panel notes that Glacier did not challenge either the return rate or the duration of flood flows that Parks Canada suggested would be required, nor was Glacier concerned that such events would have an appreciable impact on project economics.

As a result, the Panel is not concerned that the project, if approved, would somehow limit management options for the PAD. Under that scenario, Glacier would only be one of the many stakeholders that would have to be included in developing an overall management plan for the Peace River.

## 7.2 Transportation Effects

### 7.2.1 Views of the Applicant

Glacier provided evidence showing that it had evaluated potential project impacts on boating and navigation and also whether changes in the ice regime might increase the frequency of fog at the Dunvegan Bridge on Highway 2.

With respect to project impacts on boating and navigation on the Peace River, Glacier noted that the project design included a navigation lock. It explained that the navigation lock would be 10 m wide and 15 m long, located on the south bank of the river, and initially operated by project staff. It also noted that there would be a boat launch site upstream of the proposed weir and that safety booms would be installed across the river, upstream and downstream of the proposed weir to ensure that boats were prevented from approaching too close to the structure. Glacier indicated that it had not yet finalized the design of the boat lock system but indicated that it would do so and submit its Application to DFO for a permit under the Navigable Waters Protection Act if the Panel were to approve the project.

With respect to boater safety, Glacier's evidence was that if boaters were to get past the upstream boom, they would encounter a dead-water zone adjacent to the structure and would be able to ferry across the river to the shore or to the navigation lock. It did caution, however, that local turbulence in this zone might be sufficient to capsize small boats, possibly resulting in impingement of boaters on the trash racks if a capsize were to occur. Furthermore, if a boat were

to pass over the spillway during high-flow conditions, the high turbulence and hydraulic jump (keeper wave) that would form downstream of the spillway would make drowning likely. If boaters were to move upstream past the downstream safety boom, increased turbulence could capsize small boats and, if the spillway were operating, boaters could also be drawn into the hydraulic jump below the spillway. Glacier committed to developing boater safety, rescue, and education programs as part of an emergency preparedness and response plan that would be developed after the project received Panel approval.

With respect to fog, Glacier reported that it had undertaken a detailed assessment using meteorological information from the Peace River and Grande Prairie airports, as well as reports from a local observer who reported on conditions in February 2001. It described assessing the incidence of fog based on regional factors (regional air mass), topographical factors (inversions or temperature gradients in the Peace valley) and the supply of moisture from open water in the river. Using fog development equations and data on average daily humidity and minimum daily air temperatures, Glacier modelled the potential changes in the probability of fog formation due to the increased presence of open water for the months of November through March.

Based on the results of its modelling, Glacier predicted that there would be an increase in the incidence of fog during January, February, and March, since the project would result in open-water conditions at the Dunvegan Bridge during this period. Overall, it predicted that with the project, the incidence of fog during this 90-day period would increase from 41 days to 48 days, an increase of 7 days, or 16 per cent. It also acknowledged that accurate predictions of fog formation were difficult to make because the processes resulting in fog formation were very complex and micro-scale meteorological data were lacking.

As to whether this increase in fog might affect traffic using the Dunvegan Bridge, Glacier reported that the available data were too limited to determine a correlation between fog conditions, traffic volumes, and accidents. It proposed that if the number of accidents were observed to increase, remedial measures could be considered, although this would require a detailed analysis of the factors contributing to the accidents. Glacier reported that according to the Fairview RCMP, ice conditions on the bridge during cold temperatures were of greater concern than the incidence of fog, but that increased truck traffic was of greatest concern.

### 7.2.2 Views of the Interveners

Friends of the Peace stated that it believed that the project would have a significant impact on the recreational and tourist potential of the Peace River. It observed that with the project boaters would have to pass through the locks, and it suggested that this would detract significantly from the recreational and historical experience of travelling down the river. The Friends of the Peace also questioned whether the Panel had sufficient information to understand how the project might result in increased icing of the Dunvegan Bridge and how this would affect road safety.

DFO noted that for the Dunvegan project to proceed, Glacier would first have to receive approval under Section 5 of the Navigable Waters Protection Act to build or place the weir across the Peace River. It noted that Glacier had applied to DFO for this approval on March 15, 2001, but that a final design of the project, including features related to navigation, had not yet been submitted. It stated that it would continue to work with Glacier to ensure that its design adequately addressed the requirements for navigation and that any approvals would be

conditioned to protect the public's right to navigation. However, DFO noted its belief that substantial alterations of the project design would not be required to meet the requirements of the Navigable Waters Protection Act.

### 7.2.3 Views of the Panel

The Panel believes that the presence of the proposed project would affect the movement of boats past the site. This may have some effect on the tourism potential of the area, but there was little evidence to suggest that this would be either positive or negative or that its magnitude would be significant.

However, the Panel does believe that the presence of the structure would increase the risk of serious or even fatal boating accidents due to its inherent nature. The Panel accepts that Glacier has taken all available prudent steps to reduce the frequency of such accidents. Unfortunately, there was little evidence provided at the hearing that would allow the Panel to establish the relative frequency of boat travel either up or downstream from this point, and so it is difficult to determine the potential magnitude of these effects. However, while the risk of an accident may be very small, the potential consequences (i.e., the loss of human life) are serious.

With respect to the potential impacts that the installation and operation of the project might have on the Dunvegan Bridge and the adjacent roadways, the Panel has similar concerns. The Panel is concerned about the increased incidence of fog indicated by the evidence and the associated risk to traffic, which would appear to be an obvious related risk, although evidence as to correlations was not strong. Furthermore, based on the evidence, the Panel is unable to determine if there could also be an associated increase in winter icing on the bridge. As is the case with boating accidents, the frequency of such events may be low but the impacts, should they occur, could be substantial.

## 7.3 Effects on Downstream Communities

### 7.3.1 Views of the Applicant

Glacier submitted that based on its ice modelling studies, project impacts on the ice regime of the Peace River in the warmest winters would only extend about 200 km downstream of the Dunvegan site. It also submitted that the project would not affect downstream river flows because it would be a run-of-river facility that would pass the full flow of the river through or over the structure. For these reasons, Glacier concluded that its proposed project would have no impact on residents of the Peace-Athabasca or Slave deltas, including the communities of Fort Resolution, Fort Smith, and Fort Chipewyan.

### 7.3.2 Views of the Interveners

Ms. Diane Giroux, representing the Deninu Ku'e First Nation in Fort Resolution, was concerned that the Dunvegan project would have an indirect impact on the Slave River delta and the community's traditional and current use of the area. She noted that Fort Resolution is comprised mainly of Dene and other aboriginal residents who are heavily reliant on wildlife harvesting and trapping. She explained that in the opinion of the community, the Bennett Dam had adversely affected the Slave River delta by reducing water levels and the community was strongly

concerned that any change in the Peace River as a result of the Dunvegan project would ultimately affect the delta.

Ms. Giroux noted that information about historic conditions in the delta came from traditional knowledge accumulated over many generations. She explained that based on information provided by the elders, reduced water levels had resulted in willow encroachment in some areas due to the lack of annual floods, reduced beaver and muskrat populations, and decreased fish populations in Great Slave Lake.

Although the community believed that the Dunvegan project would not have a major impact on reducing water levels, Ms. Giroux stated that it was convinced that there could be some downstream impacts as a result of changes in the ecosystem. It was concerned that any such changes could affect traditional land uses and its plans to expand the tourism component of its economy, including the promotion of local river systems.

Mr. Patrick Simon, speaking on behalf of the Fort Resolution Working Committee, observed that the Peace and Slave Rivers and the Slave River delta were the life lines of the peoples of the Deninu Ku'e First Nation and was concerned that any upstream activities would ultimately have direct impacts on the downstream communities. He reported three concerns related to the Dunvegan project.

First, Mr. Simon was concerned that the project might result in further releases of contaminants, and he noted that levels of polycyclic aromatic hydrocarbons (PAHs) and mercury in river waters were already increasing. Next, he expressed concerns about whether the project would cause changes in downstream flows and the ice regimes of the Peace and Slave Rivers. He noted that members of his community had observed changes in flooding of the delta following completion of the Bennett Dam and were now experiencing difficulty travelling through the delta. Finally, he stated that increased erosion was a problem, with increased loss of trees and riverbanks.

Mr. Simon asked the Panel to evaluate the project in terms of its cumulative impacts on the rivers and the delta and advocated more consideration of traditional knowledge in making decisions involving First Nations. In final argument, Mr. Simon submitted a letter from Mr. Robert Sayine, Chief of the Deninu Ku'e, recommending that the Panel deny the Dunvegan project and indicating that the Deninu Ku'e First Nation did not give its consent for the project.

### 7.3.3 Views of the Panel

The Panel heard evidence that the project footprint, in terms of the area affected by predicted impacts on the Peace River ice regime, at most would likely extend about 200 km downstream of the project to somewhere in the vicinity of Sunny Valley. The Panel also heard that since the project would be operated as a run-of-river flow-taker, it would have no effect on flows in the Peace River during the open-water season. The Panel accepts these assessments and notes that the design and operation of the proposed Dunvegan project would be fundamentally different from that of the Bennett Dam in B.C., which has significantly changed the flow regime of the Peace River, as observed by residents of the downstream communities.

With respect to whether the Dunvegan project would affect these same downstream communities, the Panel notes that the Paddle Prairie Métis Settlement near Carcajou would be

located about 350 km downstream of the proposed project and both Fort Smith and Fort Resolution are more than 1000 km downstream from Dunvegan. While the Panel accepts the views that upstream developments can have effects throughout the rest of the drainage basin, it also believes that any such impacts from the proposed Dunvegan project on the residents of the Paddle Prairie Métis Settlement, Fort Resolution, Fort Smith, and Fort Chipewyan would be insignificant, given the nature of the project.

# 8 PUBLIC CONSULTATION PROCESS

## 8.1 Views of the Applicant

Glacier characterized its public consultation program as having been "extensive and inclusive." It identified the primary elements of its public consultation program as being open houses held as part of the development of the terms of reference for the EIA in Fairview, Peace River, and Spirit River on July 6, 7, and 8, 1999; open houses in the same three communities on August 28, 29, and 30, 2002, to discuss the results of the EIA; and correspondence and meetings with interested parties throughout the entire review process. Glacier submitted that as a result of these consultations, it was able to successfully address the concerns of many parties that had initially expressed concern about the project, including the Pembina Institute, the Athabasca Chipewyan First Nation, the Duncan's First Nation, the Mikisew First Nation, and numerous local groups and individuals, including recreational river boating groups, landowners, and local businesses.

In response to claims from the Paddle Prairie Métis Settlement that the public consultation process did not adequately solicit its concerns, Glacier submitted that it had made considerable efforts to meet with representatives of the Settlement. It argued that the Paddle Prairie Métis Settlement had not made reasonable efforts to either become informed about the project or to inform the company of its concerns. Glacier noted that its calls to and correspondence with the Paddle Prairie Métis Settlement had remained largely unanswered. It also noted that as a result of a meeting with legal counsel for the Paddle Prairie Métis Settlement in March 2002, Glacier had agreed to fund an independent hydrological assessment of the project on the Paddle Prairie Métis Settlement and it had provided a copy of this review as part of its August 2002 Information Update (Appendix E1). Furthermore, Glacier suggested that since the Settlement was located about 400 km downstream from the proposed project and since project impacts with respect to ice would be experienced at most 200 km downstream, the Paddle Prairie Métis Settlement would not be affected by the project. Consequently, Glacier believed that its consultation with Paddle Prairie Métis Settlement was more than sufficient.

Glacier noted that the Friends of the Peace also questioned whether its efforts at public consultation were adequate, but Glacier noted that the Friends of the Peace had attended the open houses listed above, participated in a boat tour of the river in August 2000, and made submissions as part of the public review process. It noted that it met with the Friends of the Peace in August 2001 to discuss its concerns, many of which related to the adequacy of information. Glacier advised that it was unable to meet the group's most recent request for a meeting to discuss the results of the latest modelling efforts because of scheduling difficulties between the two parties.

## 8.2 Views of the Interveners

The Paddle Prairie Métis Settlement submitted that it was highly likely that the project would have some downstream impacts on the Peace River that might affect the Settlement, and it recounted some traditional knowledge concerning effects that resulted from construction of the Bennett Dam. It suggested that traditional knowledge would have benefited Glacier in its assessment of project effects and it was frustrated that Glacier had never sought this information. The Paddle Prairie Métis Settlement submitted that Glacier's efforts to consult with members of the Settlement were inadequate and did not satisfy its constitutional right to consultation or the legal obligation of Glacier to consult. It noted that it had never been formally notified of potential meetings with Glacier to discuss the project, nor had Glacier Power offered to hold an open house within that community.

Speaking on behalf of the Paddle Prairie Métis Settlement, Mr. Alden Armstrong stated that he was unaware of attempts made by Glacier in 2000 to set up meetings with the Paddle Prairie Métis Settlement through Mr. Greg Calioux, who, at that time, was chairman of the Settlement. He further stated that he was unaware of Glacier's efforts in 2001 to arrange a meeting and only received notification of the requests for a meeting fairly recently. He acknowledged that Glacier had made some recent attempts to set up meetings, but noted that Glacier seemed to be unaware of or did not follow the protocols for consultation with aboriginal communities, a key component of which was a personal visit. He also suggested that Glacier erred in believing that the Settlement chairman was the only representative of the community that should be contacted and submitted that Glacier should have spent some time gathering information about the community before deciding who the key contacts should have been. Mr. Armstrong stated in cross-examination that he had never contacted Glacier concerning a meeting.

With the respect to the independent review of the project on Paddle Prairie Métis Settlement lands funded by Glacier, the Paddle Prairie Métis Settlement observed that it had never had the opportunity to review the report before Glacier submitted it to the Panel and declared that its council did not endorse the findings of the report, nor had it authorized the release of the report by Glacier.

The Treaty 8 First Nations of Alberta acknowledged that Glacier had consulted many member First Nations and noted that some of them had entered into memorandum-of-understanding (MOU) arrangements with Glacier. However, it submitted that these efforts did not constitute adequate consultation and suggested that such consultations with First Nations needed to be ongoing. It also requested that the Panel delay its public interest determination until after Glacier completed additional investigations on the social, economic, and environmental impacts of the project, and it proposed that additional consultation occur during this time.

## 8.3 Views of the Panel

The Panel notes that questions about the adequacy of an applicant's consultation often arise at hearings. While there are no simple tests to gauge whether consultation was adequate, the Panel believes that effective consultation requires that applicants do the following: identify and communicate directly with potentially affected parties; identify and communicate with aboriginal, environmental, and other groups that are likely to have an interest in the project; develop an effective communication plan that involves affected parties at an early stage in

project planning prior to submitting an application; and provide parties with sufficient information for them to be able to participate meaningfully in the decision making process.

In this case, the Panel heard that Glacier made some efforts through open houses and meetings both before and after it submitted its Application to communicate with the parties that it believed would be affected by the project. While it is obvious to the Panel that Glacier concentrated its consultation initiatives on those parties in proximity to the project, it is also apparent that Glacier made some efforts to identify and communicate with selected parties in downstream communities even though Glacier believed they would not be affected by the project.
In general, the Panel is satisfied with the consultation program undertaken by Glacier. Perhaps the largest concern for interested parties is the changing nature of the project as it developed. This can create difficulty for concerned parties trying to keep up with a large amount of new information. However, it would be unfair to find fault with the applicant for this, since many of the changes made were in direct response to concerns raised by both regulators and the public at large.

With regard to comments from some of the downstream parties that consultation was inadequate, the Panel believes that while there is an obligation of a proponent to make a real and significant effort to adapt its consultation efforts to match the needs of the various communities, there is also an obligation on the communities, if only out of self-interest, to make a reasonable effort to respond to these efforts. Clearly Glacier, as evidenced by the MOUs negotiated with some of the regional First Nation communities, was able to meet the needs of at least part of the community. The Panel is not convinced that for those communities left unsatisfied with the consultation process, the fault lies solely with the efforts of the company.

With regard to the adequacy of consultation with parties that could be directly affected by its project, the Panel notes that concerns were raised about the inability of the Friends of the Peace to meet with Glacier to discuss new technical information in a timely manner before the formal review process commenced. The Panel believes that while Glacier could have been more aggressive in pursuing these discussions, the short time period between the release of the new technical information on August 16, 2002, and the September 13, 2002, deadline for interested parties to make submissions limited the opportunity to actually hold such discussions.

## 9 PANEL FINDINGS

The Panel has carefully considered the evidence provided by all of the parties that participated in the hearing. A summary of the Panel's conclusions based on its consideration of this evidence is set out below.

### 9.1 Economic and Social Impacts

With regard to the economic and social benefits of the project, the Panel believes that, overall, these would be positive. However, the Panel heard that there are various operational constraints that may eventually affect project operations, including the effects of possible flow reductions due to BC Hydro's operations, the potential impact of ice conditions downstream from Dunvegan should the RICE model predictions prove to be correct, and operational changes that may be needed to address unexpected impacts to fish populations. The Panel notes that these operational constraints, none of which was quantified in the evidence, may result in the project

being able to generate less than the expected revenues and therefore limiting the associated economic and social benefits. The Panel is also of the view that the evidence as to a potential increase in reliability of electricity supply relating to the project is at best inconclusive.

The Panel notes that although project construction is estimated to create 300 man-years of work over a two-year period, a workforce of only three to six people would be required to operate the project over its long life. While Glacier submitted that local purchases of goods and services during project operation would be significant, these were not quantified or presented in detail. The Panel concludes that the major public benefit presented in the evidence both by Glacier and local residents would be annual municipal, provincial, and federal taxes, with property taxes, initially in the order of $1 million per year, payable to the MD of Fairview.

With respect to potential economic and social costs, the Panel finds that significant uncertainty remains as to whether the project would result in an increase in the risk of flooding in the Town of Peace River. Although Glacier made a substantial effort to quantify these risks through its modelling, the Panel notes that considerable judgement was involved in the interpretation of the model results. The Panel also notes that other ice experts did not share Glacier's conclusions or confidence in its assessment of risk and made plausible arguments as to why the project might increase the risk of flooding to the Town of Peace River. In light of the severe social and economic consequences of past floods, the Panel would consider any increase to the risk of flooding at the Town of Peace River to be a very significant negative impact of the proposed project. Even if it were to accept Glacier's contention that any increase in the risk of flooding would be small, the Panel is not prepared to accept the adverse economic and social costs.

The Panel notes that Glacier offered to undertake a number of steps, such as its commitments to address seepage and back flooding, provide for insurance in the case of flooding, and assist with the costs of additional ice monitoring, to mitigate some of these effects. While the Panel believes these to be commendable, the Panel cannot conclude that they would be sufficient to reduce the risks to the Town of Peace River to acceptable levels.

The Panel also concludes that there is a high probability that implementation of the project would result in an impact on the Shaftesbury crossing. The evidence strongly suggests that the use of the ice bridge, and possibly the ferry as well, would be reduced and that local residents and others who make use of the crossing would be adversely affected. The Panel also notes that the proponent was unable to suggest how these impacts could be reduced or mitigated.

The Panel finds that although it was unable to quantify the change in public safety risks resulting from the project to boaters using the Peace River and to vehicular traffic on the Dunvegan Bridge, it is reasonable to assume that these risks would be increased to some degree by the project. Although the actual increase in the probability of an accident occurring may be relatively small, the magnitude of these negative impacts if they occur clearly makes them significant.

With respect to the impacts of the project on First Nations, the Panel is prepared to accept that at least in terms of its effect on the ice regime of the Peace River, the "footprint" of the project extends approximately from Taylor, B.C., downstream to the vicinity of Sunny Valley, Alberta. The Panel also believes that any economic and social effects on communities living along the river or making use of the river, if they do occur, would be confined within that footprint. As a result, the Panel is unable to conclude that there is any real economic or social risk from the

project to the residents of the Paddle Prairie Métis Settlement, Fort Resolution, or the Peace Athabasca Delta.

The Panel notes that in the view of some First Nations groups at the hearing, the public consultation on the project was not adequate. The Panel regrets that efforts to reach an understanding were not successful in some instances, but cannot conclude that the efforts made by the applicant were inadequate. The Panel believes Glacier's efforts to consult were reasonable, as well as consistent with the extent of the effects of the project.

## 9.2 Environmental Impacts

With respect to the impacts on fish populations, the Panel was unable to conclude that the project as designed would result in acceptable impacts on the fish populations of the Peace River. The Panel believes that the applicant has made significant efforts to modify and improve its proposed design in order to reduce these effects to acceptable levels. However, the levels of uncertainty around the potential efficacy of these various design features remain, in the Panel's view, unacceptably high. Numerous unresolved questions remained regarding both upstream and downstream passage of fish. These included the actual design of the north shore upstream fishway and its implications for upstream passage and the eventual design of the trash racks and the implications for downstream passage. As well, the absence of clear baseline information made it impossible for the Panel to determine whether the project would meet the goals established by the various regulatory agencies involved.

The Panel notes that DFO stated that it would be possible to either mitigate or compensate for the impacts on fish habitat. However, no information was put forward regarding the extent or cost of these impacts, and the Panel is unable to conclude what the net impacts on fish habitat would be.

The Panel notes that a great deal of emphasis was placed on the use of "adaptive management" to address fisheries issues following construction. The Panel is not convinced, however, that there is sufficient flexibility in the proposed design that the use of adaptive management would be sufficiently effective in this instance.

With respect to the effect of the project on future efforts to restore historic flows in the Peace River in order to replenish the perched basins in the Peace Athabasca Delta, the Panel notes that the return rate and duration of flood flows proposed by Parks Canada were considered acceptable to Glacier, which indicated that these flows would not affect project economics. Since the Dunvegan project would be essentially a flow-taker, the Panel is prepared to conclude that the presence of the project would not have a negative effect on these efforts.

The Panel finds that while there may be other environmental effects associated with the project, such as changes to wildlife movements, increased slumping in some reaches, and increased scour in others, these effects would likely be minor and would not be a barrier to the development of the project.

## 9.3 Decision

The Panel has determined that significant uncertainty remains with respect to the relationship between the potential benefits and costs of the project. While the individual potential negative economic, social, and environmental effects of the project, if they were to occur, are substantive in their own right, their cumulative effect clearly outweighs the social and economic benefits of the project to the local community, as well as to Albertans in general. The Panel is also not convinced by the available evidence that there are reasonable opportunities to ameliorate or mitigate these potential negative effects.

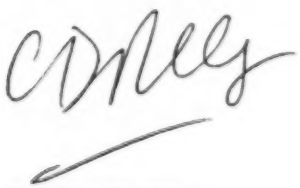
As a result of the above, EUB Application No. 2000198 and NRCB Application No. 2000-1 are denied.

DATED at Calgary, Alberta, on March 25, 2003.

**ALBERTA ENERGY AND UTILITIES BOARD**
**NATURAL RESOURCES CONSERVATION BOARD**

Brian F. Bietz
Chair, Natural Resources Conservation Board
Board Member,
Alberta Energy and Utilities Board

J. Ian Douglas
Board Member,
Alberta Energy and Utilities Board



Carolyn Dahl Rees
Acting Board Member,
Alberta Energy and Utilities Board
Acting Board Member,
Natural Resources Conservation Board

Robert Powell
Acting Board Member,
Natural Resources Conservation Board

## TABLE 1. THOSE WHO APPEARED AT THE HEARING

| Principals and Representatives (Abbreviations Used in Report) | Witnesses |
|---|---|
| Glacier Power Ltd. (Glacier) | |
| S. Denstedt | R. Keating |
| B. Gilmour | B. Johnson |
| | P. Kemp |
| | D. Andres |
| | S. Amaral |
| | B. Chilibeck |
| | R. Pattenden |
| | P. Barlow |
| | M. Miles |
| | J. Howell |
| | R. Glaholt |
| | J. Williams |
| | G. Fedirchuk |
| Government of Alberta<br>Alberta Environment (AENV), Alberta Sustainable Resource Development (SRD) | |
| G. Sprague | D. Ardell |
| C. Graham | F. Hicks |
| | D. Walty |
| Government of Canada<br>Department of Fisheries and Oceans (DFO), Parks Canada, Canadian Environmental Assessment Agency (CEAA) | |
| M. Vincent | D. Majewski |
| R. Drummond | C. Katopodis |
| | M. Bradley |
| British Columbia Hydro and Power Authority (BC Hydro) | |
| C. Low | D. Nixon |
| | D. Robinson |
| | M. Jasek |
| Paddle Prairie Métis Settlement | |
| B. McElhanney | A. Armstrong |
| Town of Peace River | |
| K. Bunn | |
| Town of Fairview | |
| J. Charchuk | |

(continued)

**TABLE 1. THOSE WHO APPEARED AT THE HEARING (continued)**

| Principals and Representatives (Abbreviations Used in Report) | Witnesses |
|---|---|
| Friends of the Peace, Canadian Parks & Wilderness Society, Peace Parkland Naturalists, Alberta Wilderness Association<br>B. Walsh | |
| Rural Electrification Associations<br>S. Sawchuk | |
| DC Farms<br>C. Liefbroer-Chenard | A. Blakely |
| Treaty 8 First Nation<br>J. Graves | |
| Duncan's First Nation<br>D. Goodstriker | Chief D. Testawich |
| Fort Resolution Environmental Working Committee<br>P. Simon | |
| Deninu Ku'e First Nation<br>D. Giroux | |
| W. Doll | |
| J. Kramer | |
| Alberta Energy and Utilities Board staff<br>J. P. Mousseau<br>T. Chan<br>K. Gladwyn | |
| Natural Resources Conservation Board staff<br>K. Stilwell<br>J. Thompson | |